ROADS AND STREETS

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Ruling Grades and Curves Between Controlling Points

Some Notes on the Prevailing Practice in Pennsylvania

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ENGINEERS are the subject of criticism at times because of apparent lack of judgment and foresight in the preparation of plans for public improvements. While these adverse comments are often unmerited, it is equally true that some are well founded on fact. It is also difficult sometimes, if not impossible, to explain in a satisfactory manner to the public those conditions which do not merit criticism. No other public utility is used as much or is as familiar to everyone as a public highway. Everyone using a road, except possibly the unfortunate engineer who made the plan for it, knows how it should be built, hence the criticisms.

Alignment and Gradient Most Important Features.—Alignment and gradient are not only the most prominent features of a highway but are also the most important. If properly arranged they should be more permanent than any other part. Property developments and public improvements usually closely follow road construction. Subsequent changes in the highway may cause dissatisfaction to the local inhabitants, as well as other using the highway; require a rearrangement of adjacent properties and add greatly to highway costs by reason of damages and the extra work of construction. It is essential, therefore, that highway engineers give the most careful thought and study to these features of design. The problems are numerous and complicated but in most cases are susceptible of solutions that will reflect credit on the designer and give satisfaction to the general public.

The problems today are vastly different from those existing 20 or 25 years ago, when horse-drawn vehicles were a dominant factor in highway traffic. Now we must provide reasonably safe highways for a variety of swiftly moving motor vehicles composed of passenger cars, large buses and heavy commercial trucks. Right angle turns and sharp angles must be eliminated wherever possible. Sharp curves must be flattened, heavy grades must be reduced and safe sight distance provided

at all points. Adding complications to the problems are the various control points which must be met at definite elevations or positions as high and low points, streams, railroads and trolleys, buildings, streets and towns. In Pennsylvania the general locations of the state roads are fixed by the legislature. The control points named in the act establish the route. Thus ideal line and grades are often prohibited. In some cases routes with spurs can be developed to by-pass the undesirable controls and always should be considered as future possibilities.

The general conditions and controls just enumerated, combined with local environment, such as the opinion of local residents, officials, and improper political influence, often act as shackles on the engineer. The engineer who is overawed by these factors prepares a design which is fundamentally weak and unsatisfactory. On the other hand, the engineer who founds his plans on sound engineering principles with due regard to future needs in the face of all opposition performs a real service, but, in addition, to be entirely successful, the engineer must sell the merits of his plans to the officials and public in the same manner that a high class salesman sells his wares. When good engineers learn to sell good designs better public improvements will result.

The Preliminary Study.—Before starting any field work or making any surveys for road improvement, a very careful study should be made of the best available maps covering the region. The United States Geological Survey maps are invaluable for this purpose. Unfortunately they are not always available, as they do not cover all areas. Control points and elevations should be studied not only for the immediate improvement but for further developments on the same road that must eventually be made. The relation of any change in the road under question to connecting roads also cannot be ignored. Sometimes a minor location that appears satisfactory would not correlate properly with a more extensive revision. This preliminary study is so fundamental and obvious that it may appear superfluous to mention it. However, it has been my observation that many engineers sadly neglect these preliminary studies. As a result, inferior or unsatisfactory location is secured or the field engineering costs are greatly increased.

Assuming that the preliminary studies have been made in a thorough and proper manner, the data secured should be taken to the field by a competent engineer for a reconnoissance which will either verify the data or will disclose new conditions which must be considered. Preliminary lines should then be run and followed up by the location and construction surveys.

Sharp Curves and Steep Grades Dangerous.—To assure reasonable safety and economy of operation of modern high-speed vehicles, direct alignment is desirable and should be secured within the limits of reasonable cost. Curves and grades should be as light as practicable. From an analysis of nearly 1,300 traffic accidents which occurred in Pennsylvania in 1926 and were scattered throughout the state, it was found that for each accident occurring on a straight, comparatively level road, 8.75 accidents occurred on curves of 10 deg. or over, and 5.1 accidents on grades of over 6 per cent. This analysis indicated clearly the danger of sharp curves and steep grades. It is our policy, where practical, to hold values well below the maximum just indicated.

In order to secure uniformity of results throughout the state and as a guide to our field engineers, certain engineering policies governing highway construction have been adopted. For the purpose of outlining these policies, the highways are divided into three classes as follows:

1. Highways carrying an average present daily traffic of 3,000 or more vehicles when improved.
2. Highways carrying an average present daily traffic of more than 500 vehicles but less than 3,000 on primary routes or more than 1,000 vehicles a day on other routes when improved.
3. Highways carrying less present daily traffic than indicated for Class 2 Highways.

Grades.—Class 1 Highways. A sincere effort shall be made to hold 7 per cent as the maximum grade excepting on grade crossing elimination structures where the maximum grade shall be 5 per cent.

Class 2 Highways. A sincere effort shall be made to hold 7 per cent as the maximum grade, but an 8 per cent grade may be used. On grade crossing elimination structures the maximum grade shall be 5 per cent.

Class 3 Highways. The grades shall be held as low as economically practical with due consideration to the importance of the highway when ultimately developed throughout its length. On grade crossing elimination structures the maximum grade shall be 6 per cent.

Alignment.—Classes 1 and 2 Highways. A sincere effort shall be made to hold the maximum degree of curvature to four and an explanation shall be given for necessity of a greater degree. On grade crossing elimination structures the maximum degree shall be six.

Class 3 Highways. A sincere effort shall be made to keep the maximum curvature below six degrees. On grade crossing elimination structures the maximum curvature shall be eight degrees.

From traffic studies which were made by our engineers, the desirability of breaking long maximum grades at intervals with lighter grades in order to enable the driver to retain proper control of the car on descending and to prevent undue slow speed in ascending was clearly demonstrated. The maximum length of maximum grade should be held to approximately 2,000 ft. where feasible.

How a Special Design Reduced Accidents.—The various combinations of line and grade are given particular attention. Efforts are made to avoid the combination of maximum curvature and grade. Therefore, maximum curves should not occur at the bottom of long or heavy grades or at the end of long tangents. These combinations can be eliminated many times by more careful study of the location, but when relocation is impractical because of difficult topography and excessive cost a special design should be devised. An example of such a problem and the solution is found on Pennsylvania Route No. 29 in the "Seven Mountains" region of Mifflin County. For many years there was a hairpin turn on a long grade of approximately 10 per cent, which was the scene of numerous accidents. When the route was paved in 1926, the hairpin turn was expanded to a 25 deg. curve with spirals; the pavement was widened to 30 ft. and superelevated 1 in. for each foot of width. The grade was also arranged so that the approach grade below the curve is plus 8 per cent, and throughout the curve and spirals the grade is plus 4 per cent. Above this the grade is plus 2.3 per cent for a few hundred feet and then ascends on a long grade varying from 6 per cent to 8 per cent. As a result of the special design, no accidents have been reported at this point since the construction was completed. It can be assumed, therefore, that the problem was properly solved.

Handling Reverse Curves.—Where reverse curvature cannot be avoided we require a minimum tangent of 150 ft. between the curves in opposite direction but endeavor to adjust the alignment to secure a greater distance. Hidden reverse curvature or a combination of a horizontal curve with a summit vertical curve are particularly unfortunate combinations and should be avoided.

Curves in the same direction with a short tangent between them, commonly known as broken-back curves, are objectionable from the standpoint of appearance and may be the source of danger to traffic. Sometimes they can be combined into a compound curve, but in this event the difference between the two branches of the curve should not exceed three degrees.

In connection with the alignment and grade, sight distance must be considered a control. Our policy requires a minimum of 400 ft. on Classes 1 and 2 Highways and 300 ft. on Class 3 Highways, but efforts are made to secure greater distances.

Inconsequential Controls Eliminated.—Inconsequential controls, unless they permit satisfactory alignment and grades, are eliminated on all new work.

It was our experience prior to the adoption of this policy that sometimes the engineers would place undesirable curvature in the alignment in order to miss a rather unimportant building or to meet a small bridge which perhaps should be rebuilt in a comparatively short time. We consider it better to eliminate such conditions on first construction rather than to make it necessary to go to additional expense on future improvements.

Results of Relocation.—As a result of our location studies for construction and replacement, the grades were greatly improved in general, and 38 miles of distance were saved by relocation in 1928. A total of 213.4 miles has been saved since 1911. During the same period 240 grade crossings were eliminated. The total saving in construction costs is over $25,000,000, while the annual saving in maintenance and operation charges amounts to approximately $750,000. This is in the nature of a permanent endowment to the motorists of all times.

Curves and grades, primary elements in considering a new project, are controlling factors in traffic hazards. Therefore, when we eliminate hazards we not only save in a monetary sense but conserve lives and contribute greatly to the pleasure and comfort of all those using the highways.

Acknowledgment.—The above paper was presented Feb. 14 at the annual meeting of the Highway Officials of the North Atlantic States.

New Mexico Highway Department Declares War on Sign Vandals

With the coming of spring and plans for the placement and repair of road signs, the New Mexico Highway Department has made a survey of the sign situation and has found that 1,800 road signs and markers were defaced in 1928. This has resulted in plans for a widespread campaign against such vandalism.

A steady publicity campaign through the columns of the press is calling the attention of people in the southwestern state to the value of these road signs, their cost, their influence on safety and their value as a service to tourists. This educational work is being followed up by pleas to all public service organizations to aid in protecting the signs.

The schools, service clubs, boy scouts and similar organizations have joined in the movement heartily. Through the New Mexico Fish and Game Commission a plea has been sent to all hunters who are thought to be offenders to some extent. Highway officials claim that some response is noted already to this campaign and that the coming season will see a material lessening in road-sign damage.

Gravel Prospecting in North Dakota

By R. A. PEASE
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Strictly speaking, the work of prospecting for gravel to be used as surfacing on our state highway system is in the nature of preliminary investigation in its relation to other activities of the highway department. However, through common consent, this task seems to have fallen into the hands of the division engineers.

When we first started this work it was considered that the ideal gravel prospector was one in whom the dorsal muscles were highly developed, and equally important that he be of limited cerebral capacity. However, we have since found that he must be a person of intelligence, and in addition, have that perseverance and patience displayed by prospectors the world over.

The Prospecting Party.—A prospecting party consists of a chief of party and from two to four test pit diggers. On being detailed to locate surfacing material for a project, the chief prepares a map of convenient scale. In the field he works in an orderly manner from one end of the project to the other, putting his test pit diggers to work at the first place he finds that indicates that holes are necessary, while he makes preliminary investigation of other prospects.

He investigates the entire territory within reasonable hauling distance of the project indicating places where it seems necessary to sink test holes. He also interviews all residents of the territory finding all places where gravel has been obtained since the country was settled. The chief of the party can, by digging small holes, tell whether or not test holes should be dug. He visits the test pit diggers at least twice daily in order to be able to direct their work and to decide whether or not their work at any location should be continued or abondoned. Many small pockets of good material are found, which on account of their limited quantity, do not warrant opening up for construction. It is often just as difficult to prove that these small pockets are of too limited an area to be used as it is to define the limits of a large pit which can be used during construction.

The Test Holes.—Test holes are dug by pick and shovel at intervals of about 50 ft. apart. These holes are 2 ft. wide by 7 ft. long and as deep as the vein of gravel, if its depth is not over 9 to 12 ft.; 9 to 12 ft. being the depth that it is safe for diggers to work without sheeting up the holes. This work is of necessity arduous and monotonous. As gravel ridges and knolls were often selected as Indian burying grounds the diggers' interest is at times stimulated by unearthing Indian relics and skeletons. While our men cannot exclaim as did Grave Digger Number One to Grave Digger Number Two on uncovering the remains of poor Yorick, "I knew him well," their discoveries are the subject of much lively conversation and speculation although a personal acquaintance may have been lacking.

The division engineer from time to time inspects the work of the chief of party and verifies his deductions and recommendations regarding material and proposed haul limits. When a pit has been located and throughly tested a plat is made to scale. Each hole is located on the plat and marked with a stake on the ground so that holes may be back-filled without losing their location. The depth of overburden and gravel is marked on the plat for each hole and an average sample of the material left by each hole before it is back-filled.

Costs.—Below appears a list of projects prospected in 1926, their length, and cost of the field work of prospecting. The cost per mile of individual jobs is of little value to one unless he were acquainted with the local conditions. The average cost per mile throughout the division however is of value since by it the cost of future prospecting can be estimated.

Gravel Prospecting Costs

Project	Length, Miles	Total Cost
76AB Burke	10.0	$ 345
78A Divide	4.0	292
159AB Divide	8.4	122
40 Bottineau	8.0	575
172 Bottineau	11.0	140
145A Bottineau	3.7	136
274A McHenry	11.0	203
118AB Mountrail 74AB Mountrail 75ABC Mountrail 277A Mountrail	40.1	471
226 Ward	5.8	163
288B Renville	6.0	130
288A Bottineau	15.0	529
270A McHenry	6.3	43
238 Rolette	6.9	180
Totals	136.7	$3,333
Av. cost per mile field work		$24.38

About $6 per mile should be added for division office overhead and supervision and depreciation on cars making about $30 per mile the cost of preliminary investigation for gravel surfacing.

Acknowledgment.—The foregoing is taken from the March North Dakota Highway Bulletin.

Motor Speedway from Florence to Pisa, Italy, Begun.—During the last quarter of 1928 work was started on the new automobile highway which will connect the cities of Florence and Pisa. An excellent motor road already connects Leghorn and Pisa so when the new section is completed, the three leading cities of Tuscany will have an avenue of rapid intercommunication. The new road will cost about 90,000,000 lire ($4,711,500), a part of which was obtained by public subscription and a part from towns and communes through which the road will pass. The road will take two years to complete and is 56 miles in length.

Basic Principles and Problems of Road Builders

Conditions in the Highway Field That Must Be Met

By E. O. HATHAWAY
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THE one common objective of all advocates of good roads is a completed system of roads, built in accordance with traffic demands. And, the citizens of this and other states of this country rightfully expect that the funds available for such roads be expended in the most economical manner, consistent with a definite fixed policy and the proper development of highway transportation. This is the duty of every highway official of this nation, be he a federal, state, county or township official, and this obligation and public trust rests equally on every road official, because the administration of the highway program in this country and this state is based upon the principle of cooperation. This equality of responsibility is not always realized by those charged with highway improvements and elected or appointed to carry out this cooperation, and the failures in the past should be a lesson that this cooperation is the most essential element in the program of securing for this state and nation a network of improved roads, planned and built in accordance with the best policies, the best materials, and in the best manner.

It is only by such gatherings as this, where we can exchange ideas, compare experiences, discuss our mutual problems, and formulate policies, that this great cooperative highway program can go forward with any assurance of a common objective.

The Importance of Cooperation.—You may feel that as a county official you are outside the realm of responsibility as far as state or federal road work is concerned. Such is not the case, for in the last analysis all roads are part of the various systems that serve our traffic. The only difference between a local and through trunk highway is in its classification, which is based upon certain facts regarding traffic and the territory the highway must serve, and these in turn define the policies for their proper improvement.

There is also this angle of cooperation to consider. A properly constructed road, capable of adequately serving present and future traffic is a credit to every one connected with highways. It is equally true that a poor road, or an improperly built one, is our mutual concern. A federal aid road or a bridge project that has proven to be a failure when opened to traffic, because of the failure on the part of the local official to secure adequate right of way, or good gravel, is as much a failure to the county commissioner as it is to the state or federal engineer. On the other hand, the rise in land values along an improved U. S. highway and the use of the pavement in transporting school children quickly to and from the consolidated school, illustrates the local value of such a road.

The whole highway system of organization and activity may be likened to the circulation system of the human body. Here we find the arteries, veins and capillaries thoroughly coordinated and who shall say which is of greatest importance. No one and no two can function if either of the other fails.

Based on this first grade principle of cooperation we have seen our road programs enlarged from township and county cooperation to that between the various states and the Federal government, and the future will see this cooperation extended between this and other nations. Yet, in spite of this growth, the county official continues to be a large factor in this progress, for it is seen that if an important local road which acts as a feeder to our state or national system is not improved, traffic is not being adequately or economically served. The old adage, "A chain is no stronger than its weakest link," applies to our public road work to a very large extent.

The second basic principle of highway development is the grouping of our various roads into systems for the purpose of fixing responsibility for their management, consistent with the traffic they bear. The traffic any highway carries is dependent upon its location, its condition, the character of the area it serves, and the population of the area.

The Two Laws of Traffic.—According to the most comprehensive traffic surveys made, traffic follows two laws, the law of distribution, and the law of density of population. In general, the distribution of highway traffic is such that 85 per cent of the traffic of a given normal area is carried on 10 per cent of the road mileage, and traffic density is in direct proportion to the population served. Thus to adequately serve 85 per cent of the traffic only 10 per cent of the road mileage of the area considered need be improved to that stage of improvement required by the density of the traffic itself. For these reasons the problem of serving traffic has resulted in the creation of road systems, such as the county trunk system and the state trunk system, and by improving these systems first we have served by far the largest amount of traffic involved.

Selection of Type of Improvement.—The third basic principle underlying the improvement of our public roads is the proper selection of the kind of improvement to adequately serve the traffic involved. The improvement by construction of any road should be based upon a traffic survey to determine the present and future requirements of service the road must render. It would be folly, for example, to inaugurate within many years to come a state-wide paving program for every road on the state highway system of North Dakota, where the traffic varies from an average daily traffic of 49 vehicles on one road to 2,800 vehicles per day on another, or where the average population of the state is nine per square mile, the average number of motor vehicles 1.5 to the mile of road, and the average wealth, $35,000 per square mile of area, as compared to a state like Wisconsin, where such a program might be economical because of a daily traffic of between 8,000 and 9,000 vehicles, a population average of 53 per square mile, a motor vehicle average of 8.8 per mile of road, and its wealth $143,000 per square mile. There are, however, places in North Dakota in the vicinity of the larger cities which require a high type of paving at the present time or in the near future.

The Law of Economic Cost.—The fourth basic principle of highway development to which I wish to call your attention is the law of economic cost. The investment cost and the cost of transportation are new factors in our road programs. We have learned through experience the life of various kinds of road improvements for a given traffic they serve, and we have ascertained the costs of operating the vehicles over these various road surfaces and grades, with the result that we can intelligently select the proper type of improvement for a given project if we know what the traffic is going to be. The type best suited for traffic is one for which the cost of the operation of traffic on an inferior type and the resulting maintenance and investment costs are less than the savings on op-

eration and investment costs on a better type of surface. From recent investigations the costs of operation are as follows:

Type of Surface	Type and Speed of Vehicles — Solid tire trucks 10 mi. per hr. per ton mi. Ct.	Automobiles 23-25 mi. per hr. per vehicle mi. Ct.	Motor busses 25 mi. per hr. per ton mi. Ct.
Portland Cement Concrete	8.0	10.0	24.0
Bituminous Macadam	8.5	10.6	25.7
Waterbound Macadam	8.7	11.1	26.0
Ordinary Gravel	9.0	11.8	27.8
Ordinary Earth	9.5	12.6	29.6

Thus the saving of operating an automobile at 25 miles per hour over Portland cement concrete pavement as compared to gravel in 1.8 ct. per vehicle mile, and for a motor bus the saving is 3.8 ct. per ton mile. For an average daily traffic of 1,000 automobiles and 10 motor busses there would be a daily saving in operating costs of $18.38 per mile, or about $6,708.70 per mile per year. By adding to these savings the cost of maintenance and the interest on the investment the cheapest road for a given traffic can be ascertained.

The National Road Program.—Bearing in mind these basic principles let us consider our national road program. When we begin to analyze our public roads from a national viewpoint we realize that highways are but a part of our whole system of transportation and that their utility must be considered and compared with the other methods of transport. Besides, America has become one of, if not the largest, commercial unit of the world. Its population has increased rapidly, its national wealth surpasses that of any other country, and therefore transportation, which is the physical means of supplying the needs of its citizens, has become the second largest industry in America, being surpassed, on the basis of dollars invested, only by agriculture. According to the latest figures available, the total investment in agriculture is 80 billions of dollars, in transportation 50 billions, and in manufacturing 45 billions. This rapid growth of transporation to second place in our industrial development is shown by its increase from an investment of 14 billions of dollars in 1900 to 50 billions in 1926. Of this total the highway industry represents about 40 per cent, while steam and electric railways represent about 55 per cent, and the remaining five per cent is split between waterways and airways.

According to figures available for the year 1927, highways rank second in tonnage carried, and first in the number of passengers carried in comparison with the other forms of transportation. These figures also indicate that railways will continue to be our prime freight system of transportation because of the fact that over 96 per cent of the freight carried on the railways is bulk freight, or what is termed—carload lots of 40 to 50 tons each.

There need be no fear that either the highways or airways will replace the railways. Each has its respective economic field in which to operate. The modern motor truck is limited to an economic haul of about 30 miles, depending on its size. The airplane at a cost of 10 ct. per mile can compete with the railways at a cost of 4 ct. per mile in the limited fields of package express, mail and passenger service, because of the high speeds attainable in the air, but even this field is limited.

Our highways do and will continue to serve both passenger and freight traffic. Highways must continue to be feeders in freight service to the railways, and in the passenger field their utility will be governed by the use of the commercial bus and motor truck, and the privately owned automobile.

Comparison of Main Transportation Systems.—Roughly, the comparison of our two main systems of transportation is between the railways, comprising some 400,000 miles of track with 66,000 locomotives, and 2,500,000 cars, and the highways consisting of 3,000,000 miles with 23,000,000 automobiles, 3,000,000 motor trucks, 123,000 trailers, and 80,000 busses. The nation's road program is primarily, therefore, the problem of serving these 26,000,000 highway units and those yet to come, at a cost not exceeding what the American motorist is willing to and can afford to pay on the one hand, and on the other, what the commercial motor truck and common carrier motor bus can economically bear in the highly competitive field of transportation, which is the short haul. Many branch railway lines have been abandoned by the railroads because of the motor bus and motor truck; on the other hand on long hauls the railroads carried their greatest tonnage on record last year, even exceeding that of the war period. Economic costs will determine which form of transport will survive.

What Additional Highway Traffic May Be Expected.—Just what additional traffic we may expect on our highways can only be estimated upon past and present production figures of the American automotive industry. Since so many of us still recall the first automobile we can hardly realize the stupendous increase in production of the motor vehicle. We are in a motor age.

In 1895 there were produced four passenger automobiles.

In 1928 there were produced four million automobiles.

In 1904 there were produced 400 motor trucks.

In 1928 there were produced one-half million motor trucks.

In 1928 there were produced 6,000 bus bodies.

According to present production records the annual number of autos manufactured is four millions, and one-half million of motor trucks, or a total of four and a half millions per year. The amount of future production is uncertain. Automotive experts believe the saturation point for autos has nearly been reached, since they number one to every four people in the U. S. and production will become one of replacements, with an allowable factor for increased wealth and population. The growth of the motor truck and motor bus is still in its infancy. Their increased use will depend on their economical costs of operation and their utility value. Just what this value is may be learned from a study of the types in use and the trend of design based upon the conditions of commerce which determine their use.

Trend of Truck Models—Percentage in Use

Truck sizes	1923 Per cent	1924 Per cent	1925 Per cent	1926 Per cent
3-4 ton and under	4	2	1.2	13
1 ton to 1½	31	30	29	74
2 ton to 4½	49	50	54	9
Over 5 tons	16	18	16	4

Thus the 1 to 1½ ton truck is the most popular type of truck and it comprises about 30 per cent of those in use, whereas the truck of over five tons capacity represents only 16 per cent of the trucks in use.

As to tires, 85 per cent of all trucks manufactured and in use are being operated on pneumatic tires, and the trend is definitely in that direction and the larger use of this type of tire.

As to busses, the 3,000 to 5,000 lb. chassis represent about one-third of the busses in use, and 5,100 to 7,000 lb. chassis about one-third of those in use, and the remainder are 7,100 lb. to 11,000 lb. This latter group has increased steadily from one per cent in 1922 to 29 per cent in 1928, showing that the trend is toward the use of larger busses with wheel bases ranging from 200 to 260 in., mounted on four or six pneumatic tires.

I need not dwell on the trend of the passenger automobile design since that is known to all. The trend is toward a smaller and speedier car.

It is seen that our public roads must continue to serve in increasing numbers the 2,000 lb. automobile, the 1 to 1½ ton pneumatic tired motor truck, and the heavier and larger 7,000 to 11,000 lb. motor bus. And, although the larger motor truck over five tons has only a very limited economic field, it represents 16 per cent of the trucks in use, and one such large truck can do as much damage to our roads as many of the smaller ones.

The highway builder, therefore, must realize that our roads must serve motor driven traffic. This means that the slow travel stage on our highways is a thing of the past. The average speed of operation is approximately 40 miles per

hour in the open country. This requires highways of lesser grades, larger, straight sections, easier curves, wider roadbeds, more substantial surfaces and pavements, longer clear sight distances on horizontal and vertical curves. It means less obstructions to traffic, such as grade crossings and narrow bridges. To build a road without these considerations is inviting disaster. Our highway accident rate at present is such that one occurs every 38 seconds. Everything that can be done to reduce or eliminate such accidents should be put into our design, construction and maintenance of our public roads.

Acknowledgment.—The foregoing is an abstract of a paper presented Jan. 23 at the annual convention of the County Commissioners Association of North Dakota.

Cooperation on the Job

Requirements for an Inspector of Highway Construction

By H. K. DAVIS

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GRANTED that cooperation between managing heads is already established and is satisfactory, there still remains a large field for cooperation between the field forces of the state highway commission and the employees of the contractor. These individuals are in constant contact, ten hours a day, every day, throughout a long construction season, and cooperation or the lack of it can leave its effect on the work dozens of times to where the relations between "higher-ups" can effect it only occasionally. Here, then, lies our greatest opportunity to improve the cooperation between the commission and the contractor; in the field; on the firing line where the work is being done.

The contractor has a responsibility in the matter as well as the commission. He owes it to the game, not alone to furnish materials, machines, and men, but to train and whip the outfit into shape so it will go. And a little cooperation along with the training will grease the bearings wonderfully. The commission on its part recognizes its duty and tries to get its men to see the desirability of cooperation instead of orders, wherever cooperation can be made to do the business. But the desired goal will not be attained until we have found a way of handing down to our respective hired men, and instilling into them, unalloyed and undiminished, that fine spirit of cooperation that already exists between contractor and department head.

But as Shakespeare says, "There comes the rub." The task is not so easy. We do not always succeed in getting the idea across to our men. Serious efforts have been made along this line by the highway commission, but not always with complete success. Also, we have no doubt that the contractors try to impress on their men the need for maintainng satisfactory diplomatic relations on the job, and sometimes fail. And the reason I believe for our failure to achieve complete success is that the individuals we are trying to educate fall somewhat short of being perfect material upon which to work. They are human, and have the usual human frailities, like all the rest of us.

A Specification for an Inspector.—You are all contractors and engineers and as such are accustomed to working with specifications. Did you ever amuse yourself by trying to write a specification for an inspector? I would wager that any contractor present could tell us a lot of things that an inspector should not be. Try that sometime. Before you have finished you will find that an inspector has to live up to some pretty high expectations. I have tried it and here are the results, not perfect, not complete, and not the only way it could be done, but sufficiently so to get a few of the requisites of an inspector up for discussion.

		Per Cent
1.	Knowledge of plans, specifications and methods	10
2.	Honesty	10
3.	Sense of fairness	10
4.	Adaptability	3
5.	Amiability	3
6.	Reserve	2
7.	Temper	2
8.	Strength of character	5
9.	Control	10
10.	Patience	20
11.	Common sense	25
	Total	100

The Requirements Elaborated.—To elaborate these requirements a little:

1. An inspector should have knowledge of the work in order to know what he is there to do. I have assigned to this point a value of 10 per cent. This is not intended to mean that he should be only 10 per cent informed on the plans and specifications by which the work is being done. He should, on the contrary, have full knowledge of such matters. But this full knowledge would in my opinon make up something like 10 per cent only of the stock in trade of a 100 per cent inspector. In other words, if knowledge of the work were all he had he would be worth one-tenth what he ought to be as an inspector. He must have the other qualities in order to be able to convert this knowledge into results in the shape of good workmanship on the job.

2. He must have honesty. This goes without saying, else the interests of neither the contractor nor the public are safe in his hands.

3. He needs a sense of fairness to guide him, for many times he is both judge and jury to pass on questions where interests of contractor and public seem to be in conflict.

4. He must have adaptability to enable him to meet and deal effectively with all sorts of conditions, and all classes of people, the itinerant nine-day hobo workman, the college graduate handling a shovel during his summer vacation, the intolerant tourist, the irate property owner, the hard-fisted straw-boss, the critical superintendent or contractor, the exacting engineer from the highway commission office.

5. He must have amiability to enable him to take a joke in the spirit that it is given.

6. He must have a little reserve, in order not to himself become a joke by too much familiarity.

7. He should have a little bit of temper in the material of which he is made, else he may be too plastic when someone attempts to wind him around his finger.

8. He needs enough strength of character to command respect, else his decisions will not be taken for what they are worth.

9. He needs control else the two preceding qualities, temper and strength of character, may be overdone.

10. He needs abundant patience to enable him to instruct a workman who learns but slowly, or to deal with one who refuses to learn at all. Also to enable him to explain to the foreman every day in an even tone of voice that the burlap must be kept wet.

11. And last, but not least, he needs a large fund of common sense, otherwise known as "horse sense," to enable him to effectively use all the other qualities.

In addition we expect him to be willing to work anywhere, any hours, to be transferred frequently on short notice, have either wet feet or dust behind his ears as the occasion may require, live in a boarding house, eat prunes for breakfast, carry his lunch, eat cold hash for supper, and do a man's work for a boy's salary.

So you see that the requirements for a 100 per cent inspector are rather high. And it may not be surprising if in some instances we fail to furnish an inspector with a perfect conception of cooperation in addition to all the other requirements.

The same process that we have here outlined of writing a specification for inspectors might be applied to workmen and foremen. I suspect, however, that I would be on safer ground to leave that to the contractor to do. If he will do it he may find that the perfect workman or the perfect foreman is hard to find in any large numbers. And it will become apparent, I believe, that on a job where these two groups of employees, each with some shortcomings, must work side by side, that cooperation will not thrive unless it secures some of its impetus from above. And a lot of push is needed from both of us if our respective employees are to get it.

Acknowledgment.—The foregoing is an abstract of a paper presented before the Central Branch of the Associated General Contractors of America.

Sheet Concrete in Erie County, N. Y.

A Pavement with a Removable Top Surface

By GEORGE C. DIEHL
Erie County Engineer, Buffalo, N. Y.

SHEET concrete pavement, as laid under our supervision in 1927 and 1929, is constructed by the use of a comparatively lean-mix base course, the incorporation of a cleavage fabric for a splitting plane at the top of the base course and the use of a 2-in. top course of rich mix and fine aggregate. The reinforcement is placed in the top of the base course. The incorporation of the cleavage fabric allows the removal and replacement of the top or wearing course as in other surfaced types of pavement. The removable wearing course also facilitates repairs where surface cuts have been made.

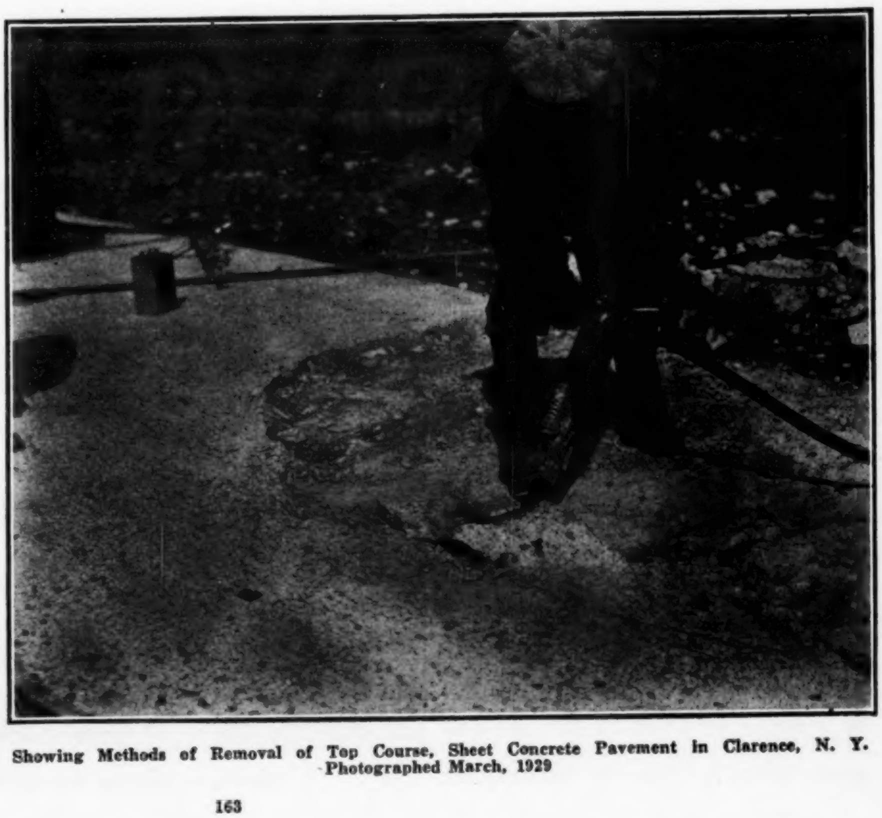
No Radical Steps Involved.—The use of the sheet concrete pavement involved no radical steps on our part because for the last six years we have been laying a so-called "two-course" pavement, consisting of a comparatively lean base course with the ordinary aggregate and a rich-mix, fine-aggregate top course.

This is ordinarily known as two-course pavement, but this title is misleading in that while the concrete mixtures in the top and bottom differ, yet the two courses are laid consecutively and before the base course has taken its initial set. Our base course for all so-called two-course pavements has been 1:2½:4 mix, while the top course has been laid of 1:1½:2 concrete with ⅝-in. coarse aggregate in the top course.

In the construction of the sheet concrete pavement, one mixer is used for small jobs while two mixers are used on the larger jobs. Where one mixer is used it is worked outside of the forms and lays about 75 ft. of base course before moving back to place the top. The base course, with the reinforcement, is laid, tamped and struck off to the desired grade. The intermediate cleavage fabric is then laid and tamped, or rolled, into the top of the base course until the mortar of the base course projects through the interstices of the fabric. The top course is then laid, using care not to disturb the level of the base course. This necessitates laying the base course dry, which gives a strong concrete with a minimum cement factor.

Prevents Failures.—Concrete roads and streets in this district have been built for the last 15 years, but because of the character of the subgrade and the character of local materials available, as well as thin design, there have been some failures. We swung from the one-course concrete road to the so-called two-course road in hopes of elimi-

Sheet Concrete Pavement, Town of Clarence, Erie County, N. Y.; Laid, October, 1928. This Picture was Taken Prior to Removal of a Section of the Top Course



Showing Methods of Removal of Top Course, Sheet Concrete Pavement in Clarence, N. Y. Photographed March, 1929

Slab with Top Removed, Sheet Concrete Pavement in Clarence, N. Y.

nating these failures by providing greater strength in the top of the pavement and a 2-in. top course which would have less absorption, better wearing qualities and less scaling. We have laid nearly 3,000,000 sq. yd. of this type of pavement during the last six years. The results fully justify the change from the one-course type and we feel that in going to the two-course work we have made real progress.

Even with this better type of construction we found, in many cases, that the concrete pavement did not answer fully the requirements for street construction. For this reason when the sheet concrete method, as developed by the Sheet Concrete Pavement Corporation of New York, was brought to our attention we deemed it advisable to test the method out in order to ascertain from our own observations the results which could be obtained.

Test Section Successful.—In the summer of 1927 we laid a test section approximately 700 ft. long and 9 ft. wide on the Rowley-Bennett road in the town of Cheektowaga. In the fall of 1927, several months after this section was completed, we removed a portion of the top course and replaced it with a new surface. The removal was accomplished by using an air hammer to break down to the intermediate fabric and then using flat point drills on the air hammer along the line of the cleavage fabric.

The results of this test indicated that wherever a 2-in. top course was laid over the cleavage fabric, the top could be removed by practical methods and at a reasonable cost. These tests, however, indicated that in constructing sheet concrete care must be taken to lay the base dry and retain a fairly uniform thickness of top course as the thinner sections of top course did not split off effectively.

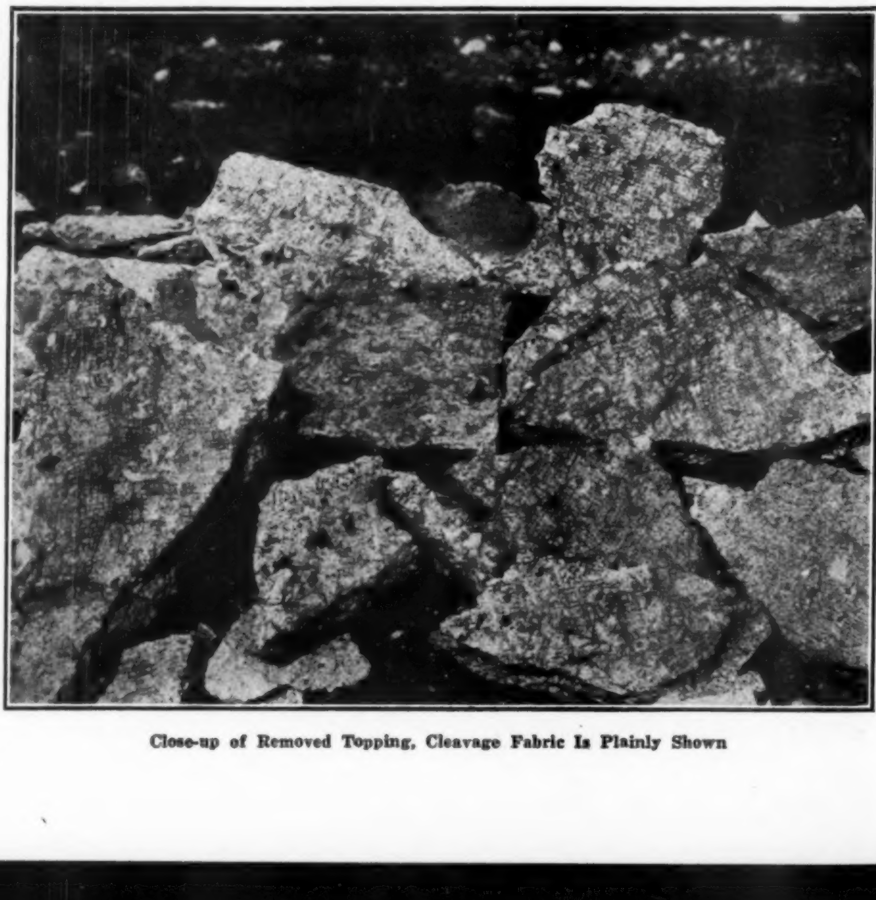
The replaced surface and the original surface are both in first-class condition today and give no indication that a cleavage plane exists.

Eighty Thousand Sq. Yd. in 1928.—As a result of the satisfactory test section we laid during 1928 approximately 80,000 sq. yd. of sheet concrete, the largest job covering 63,500 sq. yd. On one of these jobs in a high-class residential development where the owners wished to get away from the white color of ordinary concrete pavement, the top course was given a slate gray color by including in the top course mix, 1 lb. of iron oxide per bag of cement. We have awarded for construction during 1929 about 90,000 sq. yd. of additional pavement by the sheet concrete method.

From our experience to date we believe that the sheet concrete top course, laid of approximately 1:1½:2 mix, will give excellent wearing qualities. The design seems to be sound in that this 2-in. depth of concrete not only provides a wearing surface but allows designing for a full-depth beam from the bottom of the base course to the top of the surface course and at the same time gives a removable and replaceable surface which seems to justify the small additional expense of constructing by the sheet concrete method.

In addition to the use of this type on pavement work, sheet concrete has been designated for bridge work as the removable surface allows the repair and replacement of the top course without adding dead load to the bridge.

Over 3,200,000 New Cars in 1928.—For every three new cars purchased by the public last year two used cars were scrapped, says the American Motorists' Association. The total number of new cars sold in 1928 was 3,220,000 and the number of old cars scrapped during the year was 2,213,000.



Close-up of Removed Topping, Cleavage Fabric Is Plainly Shown

A Common But Fallacious Doctrine

By HALBERT P. GILLETTE

"YOU can not, in reality, prove anything by mathematics," according to Dr. Charles Lane Poor, professor of celestial mechanics at Columbia University, who has been combatting the Einstein theory of relativity for ten years. Startlingly novel as Prof. Poor's statement may sound to some people, it is quite an ancient doctrine, and none the less false because of its antiquity and the high standing of many of its proponents.

The doctrine amounts to this: Given two premises from which a logical inference is drawn, and it follows that the inference not only contains no new truth but that the drawing of the inference does not serve to establish the truth of either of the premises.

For example:

(1) All gold is malleable.

(2) This specimen is gold.

(3) Hence this specimen is malleable.

If the major and minor (2) premises are true, then the deduced conclusion (3) is necessarily true, but it is said to contain no new truth and that it does not establish the truth of either of the premises, Mill's Logic discusses this doctrine at great length, and he concludes that it is sound; but he fails to see that there is more to this matter than the mere mechanical combination of two premises to produce conclusion.

Using algebraic symbols we may write:

(1) $x=a$.

(2) $a=b$.

(3) Hence $x=b$.

And it is evident that the deduced equation (3) does not prove the truth of either (1) or (2), unless (and here lies the point) we put (3) to some test to determine whether it is a true equation. As a matter of fact Einstein did put his deduced equations to just such a test when he deduced the revolution of Mercury's perihelion and showed it to be in accord with actual measurements. His deduced formulas were again put to the test when he predicted the amount that a ray of light would be deflected by the sun, and the prediction was triumphantly verified.

So while it sounds quite plausible to say that you never get out of equations more than you originally put into them, it is really metaphysical sophistry; for what you truly get out of a deduced physical formula is a mathematical relation that you proceed to test by an appeal to facts. If it agrees (within the experimental or observational error) with the facts, the probability of the truth of the formula may be so great as to amount to certainty. And the greater the number of such agreements the greater the probability of the truth of the deduced formula if applied within the quantitative range that the original premises covered. Moreover, this probability increases not merely in proportion to the number of such cases, but in proportion to the product of their probability ratios. Thus if the probability of truth is 10 to 1 in a given case, and 100 to 1 in another case, and 50 to 1 in a third case, to each of which the formula is successfully applied, then the entire probability in its favor is $10\times100\times50=50{,}000$ to 1. Now it frequently happens that the probability ratios are much greater than those above given for illustration, so that practical certainty of the truth of a formula may often be attained by a single test of it, and a few such tests may raise its probability of its being true "a billion to one shot" or higher.

Among most scientists there is a curious lack of knowledge of the use of the laws of probability in testing the truth of theories. Were it otherwise, so many theories would not have remained unaccepted for decades, generations and even centuries. Couple this ignorance of the use of the laws of probabilities with a false doctrine such as Prof. Poor believes, and you begin to understand why the discoveries of so many scientists have met the same reception that Einstein's great discovery met for 15 years, and even now meets from so distinguished a person as Prof. Poor.

Lest it be supposed that the brief quotation at the head of this article does not fully represent Prof. Poor's position, the entire paragraph from which it was taken (as it appeared in the New York Herald-Tribune) will be given:

"Mathematical processes merely constitute a sort of specialized shorthand; they furnish simplified methods for carrying on elaborate and complicated arguments from assumed or stated premises. A conclusion is derived from certain definite premises, and such conclusion must inevitably involve and depend upon such premises. There is a mathematical law of conservation of knowledge, and you can never get out of any mathematical equations or formulas anything more than you put into them in the first place. You cannot, in reality, prove anything by mathematics."

I have indicated that this doctrine is false in that it fails to include what inevitably occurs in all rational research, namely, a testing of a deduced inference from an hypothesis (or premise) by an appeal to facts. And we have seen that Einstein put his theory to just such tests and that the measured results have agreed with his deduced results. All of which Prof. Poor ignores. Now let us consider a different sort of sophism in this doctrine that "you can never get out of formulas more than you put into them in the first place."

We venture to say that few students of geometry would ever embrace such a doctrine were they to follow the dictates of their own common sense. Take, for example, the deduced formula relating to the sides of a right-angled triangle, namely, that the square on the hypothenuse equals the sum of the squares on the other two sides. The deduction of this theorem might be called the greater "pons asinorum," because no geometrical ass can cross this bridge.

This theorem or formula is deduced by a line of mathematical reasoning that runs straight back to a few definitions and axioms; so apparently all that was put into the deduction was those few definitions and axioms. According to the doctrine under consideration, it was all hidden there when you read the first few and simple pages of your geometry.

If all that is in the "pons asinorum" is in those initial pages of geometry, why doesn't it disclose itself after a little inspection? Why must students struggle for weeks to get to a point where they can even understand what some Greek geometrician discovered more than 20 centuries ago?

When the average young man finds it none too easy to understand some of the pages of geometry, and still harder to remember them, to say nothing of originating such deductions himself, such a young man is not likely to swallow this doctrine without gulping rather hard.

It seems to me that the doctrine that all of geometry lies concealed in or embraced by the axioms and definitions is indefensible. The axioms lay down principles by which a thinking man may discover the properties of geometrical figures. Those properties were just as much concealed from view before the day of Euclid and his immediate predecessors in geometrical research as most of the properties of atoms and molecules were concealed from chemists before Dalton made that initial grand discovery that atoms unite in mathematical proportions as to weight.

It happens that anyone equipped with a pencil and paper, and a few drafting instruments, has at his disposal a geometrical research laboratory. True it is that few are taught to regard it as such a laboratory, and more is the pity; but by Euclid and by many another man of originality, this sort of paper and pencil laboratory was used to discover geometric properties of Nature. I say Nature, for I disagree entirely with those who think that men invented the triangle, the rectangle, the circle, the

ellipse, and all the other elementary geometrical forms. They existed in crystals, in the stems of plants and bones of animals, in the shapes of the sun and moon, in the paths of falling bodies, and in numberless other visible, natural things. But not till man began to study these natural forms did he begin to learn much about their properties. He is still learning, and perhaps never may cease learning, new geometrical properties. To say that these properties have always existed in Nature is true; but to say that they have always existed in the few simple premises (the axioms and definitions) of geometry is utterly false, if words are used to mean what common sense and custom has long prescribed that their meaning shall be.

What is true of geometry is true of all mathematics, in so far as the doctrine under discussion is concerned. Man often gets out of mathematics vastly more than he puts into his initial equations. Even where this seems not to be the case, careful analysis discloses that there has been an illusion. Take, for example, what Einstein put into his deduction that was not in any previous deduction, namely, his principle of relativity in its most general form. The rest of his premises consisted of established facts of physics and of mathematics. From these premises he deduced certain formulas. If results derived by their application to given cases agreed with the facts, such agreement indicated the probable truth of his principle of relativity; which truth, as above stated, was thus established. But this was not the sole test of its truth, for if he could deduce by aid of his principle of relativity a single formula that had been previously deduced from any established theory, then the probability of the truth of the principle of relativity became so great as to amount to practical certainty. He not only deduced one such formula, but many; the first two thus deduced being the formulas for relative length and relative time, previously deduced by Lorentz, who used established electric theories.

What Einstein put into his deductions was more than had previously existed in any similar deductions. Yet at first it seems as if he took out no more than he put in; but what he put in was a guess (even a wild guess) and what he took out was a certainty. The guess (his principle of relativity) became a certainty as a result of a mathematical deduction whose results were in accord not only with several established formulas but with two independent quantitive relations, one of which was already known but unexplained (Mercury's perihelion movement), the other of which was so novel as to be revolutionary in its significance (the gravitative bending of rays of light). If ever in all history a man took out of mathematics more than the mathematics itself contained, this is such an instance.

Of course the very same sorts of amazing discoveries have been made by the aid of mathematics many times. Newton's discovery of the law of gravitation was precisely the same sort as Einstein's discovery that all energy gravitates. And in just the same way that Einstein's discovery has been belittled, so was Newton's.

Curiously enough German astronomers long argued that Newton had discovered nothing new, and that all he had found was another way of showing that Kepler's laws of orbital motion were correct. (See Herschel's Essays and Whewell's Philosophy of Discovery.) Apparently those German astronomers held very much the same doctrine as Prof. Poor holds, namely, that you can't get out of mathematics more than you put into it. But I doubt not that Prof. Poor would be among the last to agree with those German astronomers of two and a half centuries ago that Newton had discovered nothing that was not already known to Kepler; for even in the alleged cold world of science, much depends upon national and racial prejudices, to say nothing of the egotisms that make many of us loath to admit that we did not discover a thing that seems so obvious when once discovered.

The part that mathematics plays in research is that of an engine or tool, by the aid of which quantitative relations are deduced. Relations thus derived are put to the test by comparing them with facts, and if agreement is found a physical discovery is said to have been made.

The engine-like nature of mathematics is well seen in the planimeter, that truly remarkable integrating machine by means of which plotted areas may be measured. An irregular closed figure of unknown area lies before you, and a planimeter is in your hand. Does the planimeter contain that area in its mechanical head? Is the unknown area somehow concealed in this machine? The question sounds ridiculous, yet it is not a whit more so than the doctrine under consideration. Just as an unknown area does not lie concealed in a planimeter, so an unknown geometrical relation does not exist in the axioms and theorems by the aid of which that unknown relation can be discovered. Whether a formula is applied by the aid of a pencil and paper or by the aid of a machine, like the planimeter, the formula does not contain the desired answer to a question, but is merely a tool that, under certain conditions, may be used to secure the answer.

It is frequently contended that logic need not be taught as a distinct science, but that all its precepts and methods are readily acquirable during the study of other sciences. And mathematics is itself held up as an excellent illustration of a science that teaches logic. But when professed and skillful mathematicians have no better conception of its fundamental nature as a tool than to believe that the tool can contain the answer sought, and that nothing can, in reality, be proved by mathematics, it would seem needless to argue that there is crying need of the teaching of research logic as such, and not merely as an incidental part of other sciences.

John Fritz Medal Presented to Herbert Hoover

The John Fritz Gold Medal for 1929 was presented to Herbert Hoover at the Executive Mansion, Washington, Thursday, April 25, at a luncheon given by Mr. Hoover to present and past members of the Board of Awards, preceding medalists, and presidents and secretaries of the American Societies of Civil, Mining and Metallurgical, Mechanical and Electrical Engineers.

This medal is the highest honor bestowed by these four national engineering societies, having a membership of 60,000. It is awarded not oftener than annually for "notable scientific or industrial achievement, without restriction on account of nationality or sex." In accordance with custom, the award to Mr. Hoover was made tentatively and without announcement in October, 1927, and was formally confirmed and announced one year later.

At the presentation on the 25th, Dean Dexter S. Kimball, College of Engineering, Cornell University, chairman of the present Board of Award, presided and gave a brief history of the medal. He is a past-president of the American Society of Mechanical Engineers.

Dr. M. I. Pupin, a past-president of the American Institute of Electrical Engineers, and a member of the Board of Award, spoke briefly of the human elements of Mr. Hoover's lifework.

Dr. John R. Freeman, past-president of the American Society of Civil Engineers and the American Society of Mechanical Engineers, and a former member of the Board of Award, spoke of Mr. Hoover's work as an engineer.

Mr. J. V. W. Reynders, past president of the American Institute of Mining and Metallurgical Engineers, and chairman of the board which made the award to Mr. Hoover, presented the medal and quoted from the certificate which accompanied the medal the citation "To Herbert Hoover, Engineer, Scholar, Organizer of Relief to War-Stricken Peoples, Public Servant."

The ceremonies ended with a statement by Mr. Hoover.

Among the men to whom the medal has been awarded in preceding years are J. J. Carty, Elmer A. Sperry, Edward Dean Adams, John F. Stevens, Ambrose Swasey, Guglielmon Marconi (Italy), Eugene Schneider (France), Sir Robert A. Hadfield (England), Orville Wright, George W. Goethals, J. Waldo Smith, Elihu Thomson, Thomas A. Edison, Alexander Graham Bell.

Surface Repairs and Treatment of Asphaltic and Tar Penetration Surfaces

Practice of the State Highway Department of Connecticut

By GEORGE E. HAMLIN
Superintendent of Repairs, State Highway Department of Connecticut

THE bituminous penetration surface offers a satisfactory solution of pavement design in the case of highways carrying a medium amount of traffic without extremely heavy loads, its construction cost being between that of the bituminously treated gravel or macadam surface and the heavy pavement required on arterial highways. It also has a definite place in the program where progressive type of construction is desired because of this medium cost and the possible rapid rate of construction with almost immediate availability for traffic.

It is possible to utilize the old macadam or gravel road as a sub-base, and at a comparatively small cost for the new surface to furnish a highway capable of taking moderate traffic with reasonably low maintenance cost.

It is my belief that this type of surface has been sadly neglected in planning the reconstruction program. This may be due to the extreme construction care necessary to obtain a satisfactory surface, and to the fact that the necessary supervision of the construction both physically and chemically to obtain the maximum value has not in general been given.

The resources of a national organization with competent engineers and chemists are as necessary in bituminous macadam construction as in the higher surface types.

Causes of Failure in Bituminous Macadam.—Failures in bituminous macadam surfaces are largely due to the haphazard method used in both methods and materials, while established principles in both of these matters may easily result in a definite standard producing excellent uniform results.

In most of the states, funds are insufficient to extend the hard road program as rapidly as traffic demands. While the main thoroughfares may be travelable at all periods of the year, there is a definite lack of secondary or tributary roads on which transportation is economically furnished both to the pleasure car and the truck in February as well as in August. This is a distinct economic loss to the community, inasmuch as the ultimate consumer must pay such transportation costs.

The dweller living five miles from the arterial highway cannot be considered unjustified in his complaint that three miles of this road are practically impassable during the spring period, even though two miles may be constructed with a high class hard pavement.

Utilizing Old Surface as Sub-base.—The bituminous surface generally follows the macadam or gravel which may be the original surface type following the dirt road. This bituminous surface, as before noted, offers an excellent opportunity for utilizing the old surface as a sub-base if additional strengthening is added where necessary. There is also no need of discarding any part of a section which through a great amount of travel has become compacted and is suitable for sub-grade use. The bituminous surface also offers an opportunity to develop additional faults in the sub-grade before a hard surface is constructed.

In general for the first two or three years a bituminous surface requires only isolated surface maintenance, depending upon construction methods and the amount of travel. Travel is most important to develop maximum value in a bituminous surface.

Treatment for Deficiency in Flushing.—In my opinion no surface of this type should be constructed where travel is insufficient to furnish the surface rolling necessary to properly compact and bring about the flushing action in the road necessary for the best results. In some cases this flushing does not occur uniformly, requiring local treatment to seal the surface and prevent water absorption. In such cases the heating kettle is invaluable. Bitumen of the proper quality and temperature poured from handpots can be broomed into the deficient spots in the surface. This treatment should be followed by an application of clean coarse sand broomed in while the bitumen is still warm.

Longer sections showing surface pitting may be treated from a pressure distributor.

It is preferable to apply two or three light rather than one heavy application, each application to be followed by a treatment of sand, and the surface honed until the bitumen and tar are uniformly incorporated and the surface voids are filled. Examination after the first application will often show that some of the surface voids have not been properly filled. A second application in the same manner should then be immediately authorized, to be followed in extreme cases by a third application, the purpose being to thoroughly seal the surface to shed water and then retain the lighter oils in the original bitumen content.

The treatment used for deficiency in flushing will also apply to extreme flushing or bleeding of the surface.

Control of Bleeding.—While rubber-tired traffic does a minimum amount of damage a slow moving steel shod vehicle, particularly if heavy loaded, will frequently tear away the surface bitumen bringing with it part of the surface stone. Each revolution of the wheel adds to the amount of material so displaced, generally resulting in two surface ruts, with excess material deposited over the roadbed.

From experience we believe that such bleeding is best controlled by an application of tar similar to that used on an ordinary macadam surface. Several light applications closely following each other may be required, but in all cases so treated excellent results have been obtained.

With proper control in the original construction, it is believed that this condition will be minimized and the greatest fault of the bituminous road reduced to a negligible quantity.

In Connecticut we have had poor success in adding stone chips to a bleeding surface. As a result in nearly all cases a rough irregular surface has developed, and, due to unequal quantities of bitumen, a recurrence of the bleeding has occurred at certain points in the highway requiring additional stone with increased surface unevenness.

A disintegrating surface resulting in the presence of pot holes tends to show a lack of previous care, either in construction or maintenance.

Our experience has been unfavorable to the general use of pre-mixed material for surface patching. Such material ordinarily is a mixture of stone chips and bitumen which forms a surface skim only and does not lend itself to satisfactory surface honing. This patching also does not in any way tend to counteract the deficiency of bitumen in the original surface. It is the general practice to treat such a surface condition superficially.

Repairing Serious Disintegration.—If serious disintegration has occurred, it is believed that the best results are obtained by cutting out the sections for the full depth of the surface. Care should be taken to cut back to a sufficient distance to develop the original pavement strength, and the section should be reconstructed to conform to

the original specifications. This work implies a definite measurement of area to determine the exact amount of bitumen to be used. For instance, if the size of the patch is 2 sq. yd., and the original specification called for 2¼ gal. of bitumen to the square yard, then only 4½ gal. of bitumen should be placed in the patch, this amount being definitely measured rather than left to the judgment of the repair man.

It is also necessary that this bitumen be uniformly distributed, and desirable that it be poured in two applications rather than in one.

Accurate Measurements Necessary.—On none of this repair work can the percentage of bitumen be determined without accurate measurement. Without such measurement irregular results occur, and fat or lean spots in the pavement, with future trouble, are assured.

Care should be taken to use only clean stone, uniform in size, and placed in layers. After the application of bitumen a hand-tamp can be used to obtain compaction around the edges. Two applications of bitumen are desired rather than one for uniform distribution, from base to surface, avoiding excess or deficient quantities in any particular part.

Much of the necessary compaction can be obtained by utilizing the wheel of the maintenance truck, a small quantity of ¾ in. stone having been thrown over the patch to prevent picking up by the wheels in rolling.

We have found that it is preferable to defer the placing of the seal coat until the patch has received compaction through travel. After this has occurred, a seal coat is applied, and the surface completed with the application of ½-in. clean stone.

While surface repairs with pre-mixed materials may in a few cases be satisfactory, in general a surface break means unsatisfactory material throughout the full pavement depth, and a deficiency in bitumen throughout such depth. Consequently the surface patch rests on unsatisfactory material, and in general requires continued maintenance. The full depth repair will ordinarily cause no further difficulty if carefully made to a definitely proportioned material quantity.

Surface Treatment.—Judgment as to the correct time for a surface treatment is the largest determining factor in the maintenance cost of a bituminous macadam surface.

If the lighter oils in the bitumen are allowed to evaporate, the material loses its plastic condition and coking results. The surface elasticity and water resisting qualities are reduced, porosity results and cracking and checking of the surface indicate the beginning of disintegration.

The purpose of the surface treatment is not alone to renew and replace that part in contact with the vehicle wheel, but to add to and restore the lighter oils lost from the original bitumen content, and to renew its elasticity and resistance to separation.

Only frequent examination of each surface will determine the necessity and time of the surface application. This examination must also go beyond the superficial stage, and must include the actual opening and examination of the condition of the pavement for its full depth. A chemical analysis of the condition of the bitumen may be justified in some cases.

It is an axiom with us to surface treat previous to the actual necessity rather than after. We attempt by this to err on the safe side, and prevent larger expensive surface renewals than are justified by possible construction or sub-grade conditions.

While it is desirable to treat at just the right time, it is far preferable to somewhat anticipate this time than to defer the treatment beyond its necessity. The maintenance cost of patching due to deferred surface treatment in the majority of cases is not justified and may easily be considered as a confession of lack of proper inspection and action in the program planning.

In Connecticut the majority of the bituminous macadam surfaces are constructed of asphalt content. On the other hand, surface treatments are almost exclusively of tar. Trap rock has been found to give better results than native stone, due to its more uniform texture, and cubical breakage, with the commercial possibility of obtaining any quantity of the desired size. Native stone is generally ununiform in texture, carries excess quantities of dust, and frequently breaks in flats rather than cubes. The segregation of the proper size stone leaves a quantity of material for which there may be no local market at a reasonable price, thus increasing original construction costs.

Application of Treatment.—When inspection and examination shows that surface treatment of a bituminous macadam is indicated, procedure is the same as in the treatment of a water-bound macadam.

In general what is termed a cold application surface tar is used. With a bituminous distributor this tar, heated to about 135°F. is sprayed and driven into the surface by pressure in an amount varying from one-tenth to one-quarter of a gallon per square yard, this amount varying with the surface condition, and the amounts stated being practically extremes of treatment. Sand is then applied in quantity only sufficient to blot the bitumen so that the combined material, if tightly squeezed in the hand, will exude a little clear tar.

Method of Dragging.—On the same day, or at the latest the next morning, the surface is dragged, first from the edges to the center, then from the center to the edges, depositing excess material on the shoulders filling the surface voids and cutting and planing any high points in the surface.

For this dragging is generally used a No. 1 hone of heavy oak construction with three cutting edges set on the same angle, or a zigzag hone with cutting edges of half the hone width, those on the right side being set approximately at right angles with those on the left. This latter hone deposits material cut with a right blade to the next one on the left, then to the second on the right, etc., finally depositing excess material through an opening in the rear of the frame onto the shoulder. If extreme cutting action is desired, the Connecticut road plane is used. This consists of runners of two steel I-beams, 16 ft. in length, carrying ¾-in. cutting teeth on the forward stretcher, and cutting edges on three other stretchers with total weight of about 1,600 lb. With this planer it is possible, by continued operation, to appreciably cut a bituminous surface softened with light tar, removing the high and filling the low points with material planed from the surface.

In obstinate cases, another immediate application of tar is used, and the treatment continued.

One old surface constructed with pitch finally yielded to this treatment, and is in satisfactory riding condition today.

Many investigations have been undertaken in the construction field, and new methods based on these studies have superseded those proven obsolete by changing conditions of traffic. Investigation of the bituminous macadam type of surface has not kept pace with that of other types.

Is there not a field here for intensive study, to return to its position in the highway program a surface of excellent possibilities, of moderate construction and reasonable maintenance cost?

It may be that in this type lies the satisfactory surface for the average condition.

Acknowledgment.—The foregoing paper was presented Feb. 14 at the 5th annual convention of the Highway Officials of the North Atlantic States.

Ohio Roads 100 Per Cent Marked

Ohio is 100 per cent marked with route markers, both U. S. and the Ohio variety. To emphasize this statement three principal cities of the state, Cleveland, Cincinnati and Columbus, are taken as an example, whereas in Cleveland and suburbs may be seen 3,040 markers of all types, of which 918 are of the U. S. type; Cincinnati has 2,012, of which can be found 996 U. S. signs. In Columbus may be found 900 markers, of which 326 are of the U. S. type. In the state generally may be found 13,256 traffic guides of the U. S. type, while Ohio guides total 50,432. There are 1,481 U. S. turn signs, 6,224 Ohio turn markers and 8,628 arrows.

Bucket Loaders and Belt Conveyors on Road Job

Methods Used on Two Pennsylvania Contracts

By J. A. GURNEY
Material-Handling Engineer, Pittsburgh, Pa.

TWO recent jobs of the M. J. McMahon Construction Co., near Pittsburgh, illustrate in a very illuminating manner the importance of careful planning and study of each individual job and its peculiarities.

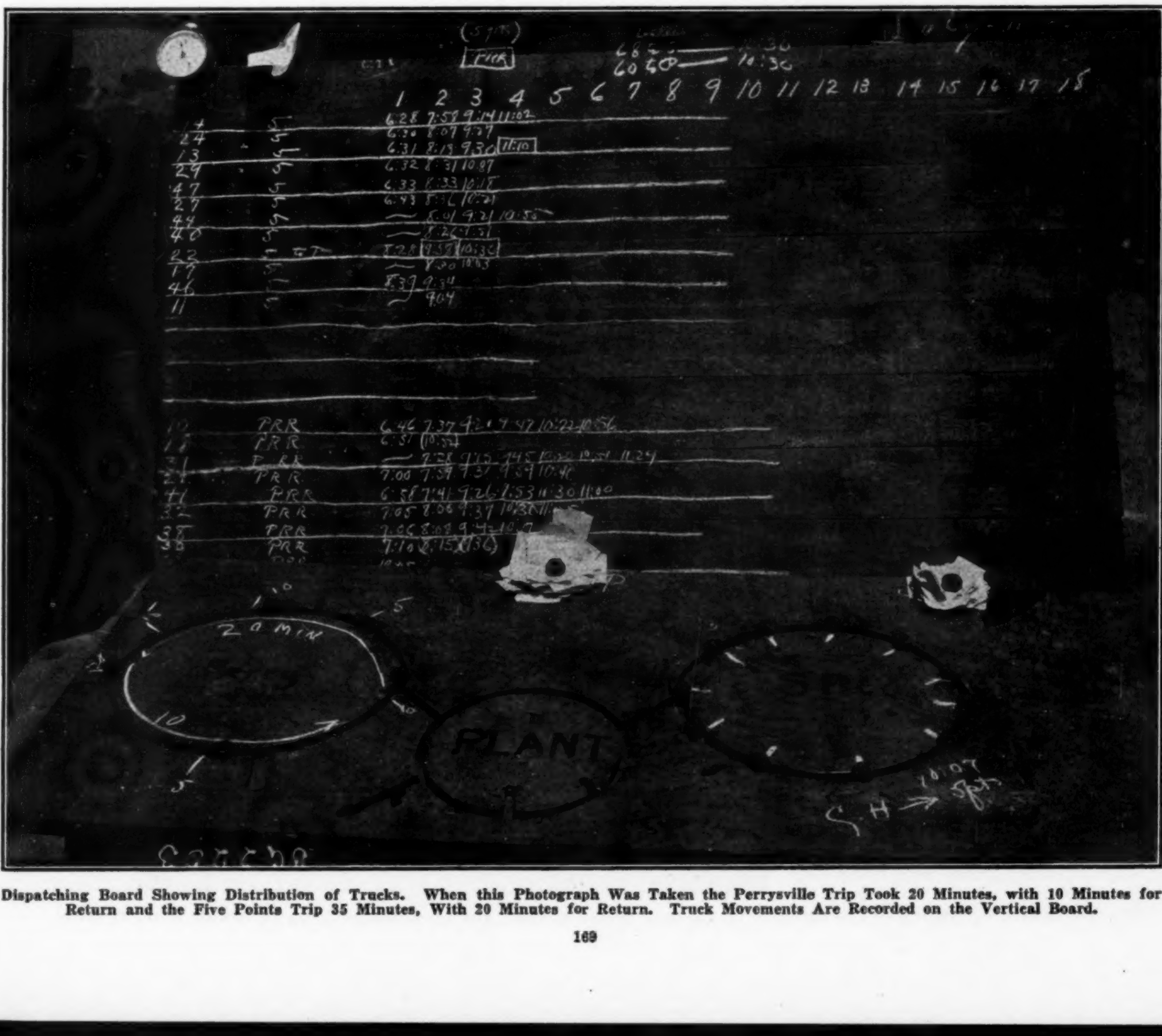
The two jobs mentioned are near Slickville, Pa., one starting from Five Points on the William Penn Highway and going toward Greensburg for 2½ miles. The other starts at Slickville proper and goes to Perrysville—5 miles. Clyde Hatton is the superintendent on the job.

The two jobs are run simultaneously, both mixers being fed from the central batching plant at Slickville. These are county roads—Westmoreland County, State Aid—and are being built on state specifications.

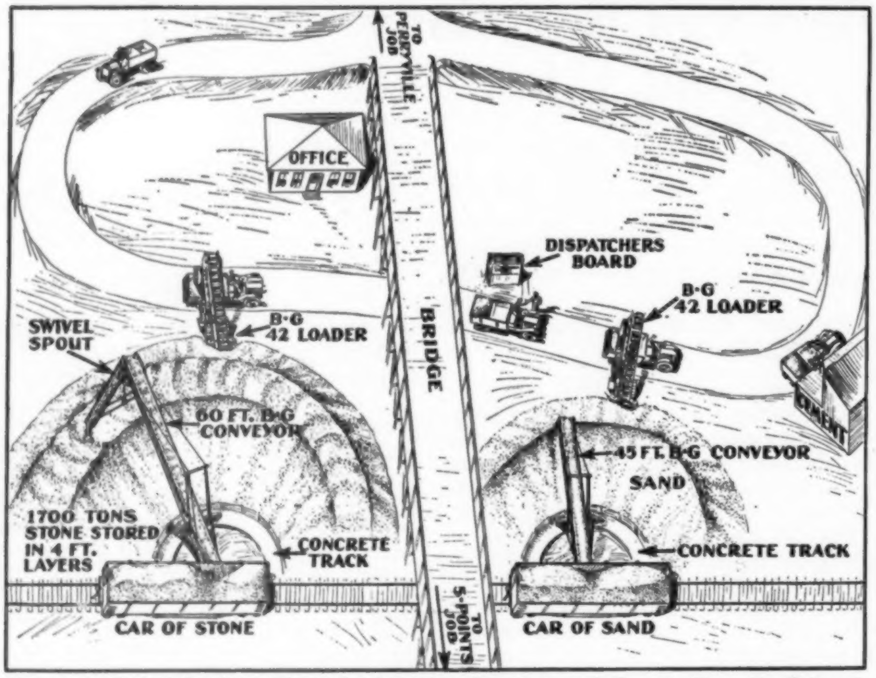
Having these two jobs so close together—there was no logic in figuring anything but running them simultaneously from a central batching plant. The contractor studied the conditions at the siding at Slickville and decided that he could advantageously use his two Barber-Greene portable belt conveyors for unloading and his two Barber-Greene crawler type bucket loaders with strike-off hoppers for reclaiming and batching. These machines had been used on his previous job, using the advance storage system. In his planning he realized that any deficiency in the supply of materials at the batching plant would be doubly costly, as both mixers would stand idle. He also had to consider the fact that the state of Pennsylvania specifications require the storing of stone in 4-ft. layers.

A 60-ft. Barber-Greene conveyor was used on the stone and the 45-ft. Barber-Greene conveyor on the sand. B-G bucket loaders with strike-off hoppers were used on the sand and stone, and a fleet of 2-batch trucks carried the materials.

The hazards of being low on stone, and of complying with the state specifications in placing it in layers were overcome by putting a spout about 15 ft. long on the 60-ft. conveyor. This spout is counter-balanced and may be



Dispatching Board Showing Distribution of Trucks. When this Photograph Was Taken the Perrysville Trip Took 20 Minutes, with 10 Minutes for Return and the Five Points Trip 35 Minutes, With 20 Minutes for Return. Truck Movements Are Recorded on the Vertical Board.



Layout at Central Batching Plant Showing How Aggregate and Cement Were Handled and Trucks Dispatched

easily swung around 180 deg. with one hand. Also the machine itself may be swung an equal number of degrees, as the wheels are swiveled; a cement track was built to make this easy. A similar track was built for the sand conveyor. As much as 1,700 tons of stone have been stored at one time with this method, allowing an ample supply for both mixers, enough to take care of any reasonable shortage, or railroad tieup—and storing in 4-ft. layers even more easily than with a crane.

On loading the 2-batch trucks the Barber-Greene loaders with strike-off hoppers proved most effective both in speed and accuracy.

The operators have the strike-off hoppers on the loaders full before the trucks drive under. When the trucks are beneath the hopper, only a few seconds are required for the first batch to be emptied. On the sand about 20 seconds are usually required to refill the hopper for the second batch, and on the stone about 45 seconds. As an average the trucks stay under the stone loader 1½ minutes and under the sand loader one minute, getting both batches. Getting the stone, dispatching ticket, sand, and cement usually requires less than five minutes.

The road being built is 16 ft. wide, 6 in. center and 8 in. edge. A 1:2:3 mix is used, each batch staying in the drum 1¼ minutes. An average of 1,000 ft. (500 ft. each road) per day is being poured on both jobs with a maximum for one 10-hour day at 1,303 ft. Two Foote mixers are used, which started at the extreme ends of the job and travelled toward the batching plant.

Thirty 2-batch trucks were being used when the writer visited the job.

Truck Dispatching System.—The contractor saw an opportunity to beat the problem of keeping exactly two trucks waiting for the mixer all the time, no more, no less.

After talking this problem over with the superintendent, Clyde Hatton, the two worked out a very efficient dispatching system that has been in effect several weeks and has proven that an average of two trucks per day are saved by the use of it. The mixers are never in want of material—nor are an excessive number of trucks (three or more) ever waiting at the mixer.

A board which is illustrated on another page was made to keep the time, number of trips, etc., on each truck. Then the board shown at the lower part of the picture was made for the purpose of telling at a glance—how many trucks are at the batching plant, how many are waiting at each mixer—how many are enroute going out on each job—and how many are returning from each job.

As the illustration shows, the board has three circular slots—one representing the central batching plant—one representing the route to and from the Five Points job and one representing the route to and from the Perrysville job.

The point on the extreme ends of the two large circles represents the point where the mixers are. Each truck is represented by a disc which slides in the slots. The routes to and from the mixers are marked off in 5-minute graduations. For instance, when the photograph was taken of the board, the trip to the Perrysville mixer with a loaded truck was twenty minutes. The return trip with empty truck was 10 minutes. The trip to the Five Points mixer was 35 minutes and the return trip was 20 minutes.

When the job starts in the morning the board has none of the discs on it. When the first truck leaves for the Perrysville job a disc is put on the circle —and as one leaves for the Five Points job, a disc is put on that route. Every 5 minutes thereafter these discs are moved forward one graduation. The trucks that start after are moved in a similar manner. As the trucks return to the batching plant, if they are not exactly synchronized with the corresponding discs—the discs are placed in the proper position.

Trucks are sent out on each job until


Conveyor Unloading Sand; Also Shows Cement Track for Wheels of the Conveyor

Bucket Loader Batching Sand; Cement Shed and Sack Loading Platform in Background

the discs show that there are two trucks waiting at the mixer. The accuracy of the board is increased by the fact that each driver is given a slip by a dispatcher at the mixers. This slip tells exactly how many trucks were waiting at the time. The slip is in turn handed to the dispatcher at the dispatching board at the central batching plant. When the board shows that more than two trucks are waiting at the Perrysville job—and only one is waiting at the Five Points job—the next Perrysville truck that comes in at the central batching plant is transferred to the Five Points mixer—and the discs are moved accordingly.

The dispatchers at the mixers also write on the slips certain essential data such as breakdowns, weather conditions, conditions of the road, etc.

This simple dispatching system saves two trucks a day. Seeing the importance of intelligent dispatching, the contractor wants to get even more efficiency out of his trucks. He is now planning the installation of a telephone line. There will be a phone at each mixer, each pump—and at the central batching plant. Virtually 99 per cent efficiency in dispatching can be gotten when this system is installed. It is estimated that for trucks $100 per day will be saved on trucks when this system is put into effect.

Conveyor and Bucket Loader Handling the Stone Aggregate for the Two Road Jobs of McMahon Construction Co.

Harry J. Kirk, Now Consulting Engineer

Harry J. Kirk, until recently Director of Highways, State of Ohio, has announced the opening of an office in Columbus, O., as consulting engineer. He will specialize in highway and street problems. His wide experience on highway construction and maintenance should be a valuable asset to him in his new field of endeavor.

Mr. Kirk is a graduate of Defiance College and Notre Dame University. He was first employed by the Ohio State Highway Department in 1914, starting in charge of minor maintenance operations. He was successively promoted to division engineer, maintenance engineer, construction engineer and chief engineer of the department. In this latter capacity he served for three years and was finally advanced to the highest post in the department; director of highways, and a member of the governor's cabinet. His term ended with that of Governor Donahey's in January.

For many years Mr. Kirk has been active in the Mississippi Conference of State Highway Departments and the American Association of State Highway Officials, being well known among those in the highway field throughout the country. He has also been prominent in the work of the Highway Research Board of the National Research Council, being at present chairman of the Committee on Highway Finance of that organization. He is now serving as vice-president of the Engineers' Club of Columbus.

New Mexico Had $3,000,000 Worth of Roads Under Construction as Last Construction Season Closed

A survey by the State Highway Department of New Mexico of roads under construction in March showed that there were $3,000,000 worth of projects under way. These are all projects from lettings in 1928 and do not include 1929 lettings of which there have been none as yet.

Two hundred six miles of road are included in this price estimate with three major bridges for which no mileage is figured. The longest project is 26.11 miles in length. The most costly project is a gravel job 14.78 miles in length which is being constructed at a cost of $260,000.

Methods of Financing Highway Construction

By CHARLES M. UPHAM

Secretary-Director American Road Builders Association

IN connection with the early history of highway finance in this country, it is perhaps fitting to go back to the stage-coach period. At this time highway construction was mostly local in character and often the construction was carried on by residents of communities furnishing labor, and the work financed by such funds as were considered necessary secured from local treasuries.

The Toll Road Period.—Toll road companies were formed at this time and the toll road had its greatest popularity during this period. At first it was thought that the toll road would be the universal means of transportation, but it was soon learned that the steel rail was more economical, especially for long distances.

The irritation caused by private toll roads, the failure of their promoters to keep them in repairs, and the growing recognition that the interest of the entire public was bound up in the transportation which the vehicle provided, forced a relinquishment of these toll-road franchises and today there are virtually no toll roads in the United States.

The stage-coach or toll-road period was followed by the development of the steam engine which may be termed the next period, and an extensive development of the country took place at this time. The first real inspiration for an extensive program of improved highways occurred with the advent of the bicycle and it is an interesting reflection that the papers of the day commented at length upon the costly folly of constructing roads which cost $1,000 a mile.

Perhaps the impelling motive for highway improvement even in the early stages was the fact, quickly recognized, that road development immediately reacted to the benefit of the community possessing them. As good roads were extended from town or city, the transportation and commerce centering there showed a marked increase. The farm, hitherto outside the economic zone of production, was made available, property values were enhanced and as a result a spirited rivalry of road building ensued between centers of population all over the country, and general prosperity followed.

History of Highway Finance.—Highway finance which should be treated as an investment, is a problem of taxation, and the direct or "pay-as-you-go" policy of expending funds was the first method used for financing highway improvement. The motor registration increased with great rapidity and demanded many miles of improved highway. Difficulties developed in securing sufficient funds from current income to provide for the necessary construction, without increasing tax rates to undesirable or unbearable proportions. Since sufficient mileage of modern roads could not be built rapidly enough from current funds without a heavy tax burden, and keeping in mind the economic necessity for this mileage, the practice was resorted to, of authorizing highway bonds to be paid for, over a period of years from the taxes on land. And these in turn, have in recent years been largely supplanted as far as state highways are concerned, by the automobile, gas and registration taxes.

Massachusetts, New Jersey and New York took the lead in providing for the issuance of highway bonds; Massachusetts approving the law relating to bond issue in 1894, quickly followed by the other two states. The local units in these localities made their initial ventures in bonding at about this time. This method of financing rapidly gained popularity and up to 1828 twenty-five states had resorted to state highway bond issues and forty-seven of them have resorted to county bond issues, North Dakota being the only exception.

Bonding Versus "Pay-As-You-Go."—In considering these two methods of financing certain principles have been set forth which are the result of the experience in highway financing which this country as a whole has passed through, and which should afford some assistance in making a choice.

The bonding plan requires a definite program in advance, a legislative enactment which places the responsibility of the construction program in the hands of a reliable and competent commission and which governs mileage in system and specifies location of highways as to origin and destination. Large sums of money spent without restrictions by law, may not be expended where they will benefit the greatest economic needs. Therefore, the necessity of preliminary road-laws covering bond expenditures is strongly recommended as a safeguard for public funds.

The bonding plan is recommended when the program is just beginning and before any great part of the system has been completed. It furnishes a means of more rapidly meeting the popular and economic demand for roads, and its great advantage lies in the early availability of the highways. This response through a rapid construction program to popular requirements for better and more lines of communication always starts a series of reactions that result so favorably on the industrial and economic life of the country. It permits quick construction of programs large enough to secure the advantage of big contracts and low prices. It makes the building program more rigid and tends to remove it from the easy manipulation of local politicians.

The "pay-as-you-go" plan should be used when the construction of the highway system is more advanced and should be used when the road program is nearing completion. It may be successfully used if annual revenues are plentiful and should be used in any case where the present bonded indebtedness is so heavy as to have affected adversely the public credit of the state or county.

In making a choice of financing an essential detail is pointed out. If $100,000 is to be spent by the "pay-as-you-go" plan on ten miles of construction and the annual highway fund is $10,000, the cost is $10,000 per mile and it will take ten years to build. With a $100,000 bond issue, serial type, 4 per cent maturing in a 20-year period, the cost of the bond issue will add $42,000 to the cost of the highway, so there must be added $4,200 to the cost of each mile of roadway, but the entire 10 miles of newly constructed highway would be immediately available.

If this immediate construction of the entire mileage accommodates enough traffic to save or earn the difference in cost, the bond issue is always justified.

Considering the problem from a viewpoint of possible mileage and highway use with a given income and taking for an example a county with an annual construction fund of $14,000, a program extending over a 20-year period and operating on current funds would construct 28 miles of roadway at $10,000 a mile and would finance the construction of 1.4 miles of roadway per year. The highway mileage available over a period of 19 years would be 14 miles and equals in terms of road usage 266 year miles.

Using bonding plan, choosing 20-year, 4 per cent serial method, and annual construction fund of $14,000, it is found that this figure would pay interest and principle on a $200,000 bond issue. This would construct at $10,000 a mile, 20 miles of roadway in one year and the total mileage would be immediately available, this considered over a period of 20 years or the life of the bonds would total in terms of road usage 380 year miles. The difference between this figure and 266, which is the total under the "pay-as-you-go" method, equals 114 year miles. This difference represents 43 per cent greater use of the highway under the bonding plan over the same period of years and if this improvement of transportation facilities

accommodates sufficient traffic to justify its immediate construction, then this difference may be considered the measure of advantage for the bonding method of financing.

In summary, the "pay-as-you-go" policy in this case, would finance the construction of 40 per cent greater mileage from the same annual income, but would take 19 years longer to build and would provide 43 per cent less mileage for use over a 19-year period. Under these conditions, unless the economic condition of the locality is unusual, the advantage of the earlier use of the small mileage would justify bonding.

Bonds.—In considering the issuance of bonds, the three forms in general use are, term, serial and annuity. Term bonds mature after definite periods and require a sinking fund. Serial bonds are retired annually or at other periods, a fixed portion of the issue being retired at each maturity date. The annuity is similar to the serial, but the retirement plus interest are maintained at a constant figure. The serial bond is the cheapest and is the most popular for highway financing. This type is particularly adapted for financing operations which by their very nature involve a depreciation of property. A highway is in part a depreciating property. If the retirement of bonds is faster than the depreciation of the highway, then the difference between outstanding bonds in any one year and the value of the highway may be termed the margin of safety.

Instances are not lacking where errors in expenditure of bond issue funds for highway purposes have occurred. These instances are invariably due to mismanagement of the construction program rather than to defective principles of bonding and some of the more common errors will be cited later.

In states and counties where road financing by bonds has been pushed forward on a comparatively large scale and the funds expended judiciously, there has been a notable increase in the use of motor vehicles and growth of prosperity. Inasmuch as the gas tax and registration fee are among the most satisfactory methods of highway financing, the reaction of the improved highway, on automobile registration, is one of the most important developments of capitalization of funds for the purpose of bond issue financing.

A comparison of states having highway bond issues with those which have used other methods of financing indicates a marked advantage in automobile registration for the bonded states for the year 1927. Using figures compiled by the Bureau of Public Roads the total increase in automobile registration in 1927 over the preceding year amounts to 1,131,848 motor cars and trucks. The twenty-five states having bond issues show a total increase of 716,931 vehicles, or an average of 20,677, which is about 6.5 per cent. The unbonded twenty-three states and District of Columbia show an increase of 414,918 vehicles, an average of 17,288, which is about 4.3 per cent.

North Carolina's Experience.—North Carolina leads the entire country with an increase of 11.8 per cent. This state is an outstanding example of highway financing by the bond method and it is perhaps advisable to note its procedure and resultant development.

In 1921, the North Carolina General Assembly passed the "Road Law" which authorized a $50,000,000 bond issue for the construction of a highway system connecting county seats and principal towns. This has since been increased to a total of $115,000,000, which is the total authorization to date and is nearly all outstanding. In addition the State Highway Commission has spent on road road construction about $35,000,000 in Federal Aid, automobile and participation funds, bringing the total expenditure to about $150,000,000. As a result of this expenditure, North Carolina has about 5,000 miles of completed surfaced highways; about 3,500 miles of which is cement concrete or asphalt on a concrete base.

North Carolina has exhausted the funds received from the sale of its bonds, and the program started in 1921 is very nearly complete. It has a "system of highways running to all county seats and principal towns."

The ultimate cost of retirement of this large bond issue should now be given consideration. The serial bond plan has been utilized here, the first maturity taking place in 1929 and the last one in 1964. The interest rate on the total averaging 4.25 per cent. The ultimate cost of this financing, assuming that the bonds are not retired earlier than planned, will amount to about $70,000,000 in interest and amortization charges, which is a total cost of $185,000,000 in principal and interest, but according to actuarial computations the sinking fund requirement for the longer term serials will be sufficient to retire $65,000,000 about ten years before the last bonds mature. This will materially decrease the carrying charges and discharge the total debt about 1953. The maximum life of the bond issue under these conditions would be less than 30 years. The entire expense attached to bond retirement is taken care of by revenues received from gasoline tax and registration fees, but the full faith, credit and taxing powers of the state has been placed behind every bond and note issued.

That this method of financing in this instance is self-sustaining with sufficient surplus for further construction operation is evident from publication of recent figures. For the year ending June 30, 1927, the receipts of the gasoline tax and registration fees were sufficient so that the State Highway Commission has a surplus of approximately $6,000,000 for road construction purposes after all annual charges had been made, including interest, sinking fund and maintenance of highway system. This figure is estimated to be about $8,000,000 for 1928.

The highway system as an investment or producer of wealth, and figured from a standpoint of economic saving, shows some astonishing results in North Carolina. Using figures computed from the traffic census and the saving in operating costs demonstrated at the experimental station of Iowa State College, the economic saving in operating costs alone would amount to $60,000,000 annually. This is computed from mileage figured from automobile consumption of gas, which is 3,000,000,000 car miles for current years, and a saving of 2 ct. per mile by the use of improved roads. Even if this total was reduced one-half to allow for any possible adjustment of operation off the surfaced highways it would still show a saving according to the experimental station ratios, of about twice the total license fees and gasoline taxes paid by the motorists in the whole state for the year just ended. Other savings through good roads in this instance are numerous, but somewhat difficult to translate into figures. The operating savings, alone, however, would justify the $115,000,000 bond issue that the state is requiring automobile owners to liquidate with taxes from savings they effect through good highways. It is safe to estimate that the saving to motorists, on account of the highway system, may amount to between five and six times the total motor taxes paid in a year.

Had North Carolina attempted its program of highway construction through use of current funds, it is evident that its present system of completed connecting highways would have taken years to construct and the resulting moderate increase in automobile revenues would necessitate augmenting this form of taxation by others more burdensome.

Use of Proceeds from Bond Issues.—The proceeds from bond issues should be used for permanent improvements as possible, that is, grading and drainage structures and any part of the surface that may have a salvage value; these are estimated to be 40 per cent to 60 per cent of the investment and are permanent. Funds from bonds should never be expended for temporary road surfaces on unimproved grades. One southern county issued bonds to the amount of $300,000 and spent it for light grading on an excessive mileage of roads. The improvements contemplated should outlast the bond issue. Bond money should never be spent on maintenance. Lack of engineering supervision, necessary economic surveys, and poor highway administration have accounted for wasted funds in many instances.

There are instances where state bonding has been pushed ahead too rapidly without sufficient planning as to clas-

sification and location of highways. One state committed errors in her building program, due possibly to hurried planning, or possibly to the fact that the first bonds were issued in 1910 and errors were made in planning for future traffic requirements. In this state the bonds issued to date amount to $73,000,000 and will ultimately cost in principal and interest $132,000,000. The payment period will extend to 1965. This is evidently expensive financing, the carrying charges amount to about 80 per cent of the principal. The life of the bonds are from 40 to 45 years, which is too long and should have been issued from 25 to 30 years only.

The possibility of wasting funds may be minimized by taking into consideration the following principles:

(a) State Highway bonds should be serial in form and should mature over a period not exceeding thirty years. The annual charge decreases very slowly from this point, whereas the total cost increases rapidly.

(b) County bond issues should be serial in form and should mature over a period not exceeding twenty years. Interest rates on county bonds are as a rule higher than those on state issues. The use of the serial bond eliminates the hazard of a large sinking fund which is in constant danger of violation.

(c) Maturities should be arranged so that the annual requirements of principal and interest will be as nearly uniform as practicable. This also avoids the danger of accumulation of large sinking funds and a fluctuating tax rate.

"Pay As You Go" Plan.—Virginia is a very good example of a state carrying on its highway program by the pay as you go method. It commenced its major operations in highway construction in 1919 and has regulated the extent of its improvements by the amount of annual income. Virginia receives its highway revenue from a 5 ct. gas tax, license tax, state convict force, federal aid and mill tax, the total amount for construction purposes during 1928 total about $8,000,000. The state highway commission borrowed about $9,000,000 of county bond issue funds some years ago and have since refunded the money and assumed the amortization of the bonds. The counties are now receiving a 1½ ct. share of the gas tax prorated according to their respective real estate valuations.

Virginia has spent on construction since 1918 about $60,000,000 and has graded and surfaced approximately 3,300 miles of highways, including about 1,600 miles of hard surface, bituminous macadam predominating. The state policy of financing is a typical example of the "pay as you go" plan, and with the cessation of use of county funds for state highway improvement, the objectionable feature has been removed.

Georgia receives its funds for roads from Federal Aid, a 4 ct. gas tax, registration fees and county aid. It is now financing with current funds, but the method differs from Virginia through source of income and method of distribution of funds. It has a county debt of about $23,000,000, which represents money that has been received from county and district bond issues. This revenue represents a large percentage of the state highway total income. This policy of county-aid financing necessitates the expenditure of funds in the counties from which the funds are received, and it follows that the richer counties are supplied with roads, whereas the poorer counties are lacking. In many instances this effects and delays the completion of the state system and results in lack of coordination, curtailing the development of through highways and causing impassability.

Georgia has spent since 1918 about $65,000,000 on highway construction and has graded and surfaced about 2,500 miles, 900 miles of which is hard surfaced, concrete predominating. Georgia had for construction funds in 1928 about $8,000,000.

Results of Different Methods of Finance.—Now to observe the effects of these methods of financing on the automobile registration, which is an indication of prosperity and progress. In 1910 there were less than 5,000 automobiles in any of the three states. In 1919, about the time the road program started, Georgia led with 125,000 registrations, Virginia was second with 105,000 and North Carolina was third with 65,000. Virginia's registration was greater than that of Georgia in 1922. North Carolina's increase was sufficient to pass Georgia in 1923 and led Virginia in 1924. According to figures recorded in October, 1928, Virginia had 50,000 more registrations than Georgia, and North Carolina had 100,000 more than Virginia.

The trend of motor vehicle registration per capita in the three states is as follows:

	Georgia	North Carolina	Virginia
1910	145	1350	760
1920	20	31.5	17
1923	17.2	13.1	9.3
1925	13	8.3	7.3
1928	10.5	6.4	7.1

It is undoubtedly true that automobile registration is limited only by population and the ability of the purchasing public to buy. The rate of increase of registration is a function of highway improvement, each one reacting directly on the other and the common cause is the demand for easier and cheaper communication. North Carolina is an excellent example of resultant large increase in the use of motor vehicles from the very rapid completion of a well planned connecting mileage of roads.

The present system of financing in Virginia is sound and is a good example of financing from current income. It would seem, however, from comparisons drawn herein, that Virginia could have profited by a speedier program and inasmuch as it has some distance to go with its construction, a bond issue of suitable proportions would evidently react to its advantage.

The best results in highway financing have evidently been obtained under strict business management and efficient engineering. A very sound principle of administration and finance might read somewhat as follows: "Funds for state highway construction purposes should be state funds and expended under the direction of the state highway commission, to secure the best results."

That there has been and still is violation of this principle in some states is evident. The use of county funds for the purpose of state highway construction not only exhausts the credit of the counties but seriously curtails the development of local highways. States should assume the responsibility of financing state systems, thus eliminating this undesirable distribution of highway funds.

The advent of gasoline tax and registration taxes has solved the problems of state highway taxation to a large extent. Inasmuch as 75 per cent of the total expenditures on state systems is derived from gas tax and license fees, at the present time, it would seem a possibility that these might become the absolute source of revenue in due time.

The gas tax made its initial appearance in 1919 in Oregon, and has since been adopted in all but two states, with rates ranging from 1 to 5 ct. per gallon. The total revenue received from this tax in 1926 was $188,000,000 and amounted to nearly $257,000,000 in 1927, making an increase of $69,000,000. With the advent of this means of highway income, state tax levies on real estate are diminishing, thus improving the situation in the local communities. Local highways in most instances should be financed through local taxes, and with the abolishment of the state road tax on real estate, the counties are free to utilize their entire taxing power toward the development of their respective systems. This change in taxation has given great relief in certain states through the south, where an extensive school program is in effect and a great many counties are laboring under a heavy tax burden. Financial distress in county highway development, however, can quite generally be traced to mismanagement in the administration of their road funds, and a good many of them are rather heavily in debt with very little permanent mileage to show for their expenditures.

Highway financing, by the two methods now in use, has been quite generally standardized. From errors made in the past, valuable lessons have been learned and by utilizing the information gleaned from successful operations and profiting by the mistakes of less fortunate, a method of financing highway construction should be possible for

either state or county system which would include a maximum of efficiency and a minimum of waste.

With any method of financing, the value of detailed study of the economic condition of the state or county or city, as well as the traffic conditions cannot be over-estimated. No road should be improved by expenditure of public funds in excess of its earning capacity. The return to the public in the form of economic transportation is the sole measure of the justification for the degree of improvement.

Conclusion.—In considering methods of financing, it is necessary to first determine the degree of indebtedness, extent of highway income and degree of completion of system. Classification according to degree of completion is recommended. The fact that much of the improvement of highways is lasting, and may be in use from 20 to 50 years would justify a distribution of costs to cover several years, thus causing the user to pay. This is evidently fair distribution and so with states or counties which are in the preliminary stages of highway construction and where it has become necessary to proceed with construction so rapidly that the expenditures would cause excessive tax rates, then the costs should be deferred and financing by bond issue is justified and recommended.

This reasoning would not apply to states or counties where highway construction is well on the way to completion and the bond issue method should never apply where states or counties have indebtedness which effects the public credit.

Current funds should furnish sufficient revenue for normal financing in states where the road program is well under way to completion. Bonding is not recommended where states are in this condition. Maintenance and reconstruction are the factors under consideration in this instance and should be paid for by current revenues. Bonding, however, may be used for special projects or extensions to the system.

It is well to keep in mind that sound planning and good management of the loan in bonding operations is of greatest importance. The question of the debt itself is relatively of less consequence, for it is a well established business principle that extension of credit within safe limits is necessary for maximum results.

In the final analysis the question is not merely whether a community shall incur a debt, but whether the maximum economic efficiency and the full development of the public wealth will be best promoted by using public credit.

Acknowledgment.—The foregoing is a report presented by Mr. Upham, Chairman Committee on Highway Finance, at the 1929 convention of the American Road Builders Association.

Securing Maximum Utility of Highways

Correlation of Right of Way, Roadbed and Slab Widths

By CHAS. F. BOEHLER
Engineer of Design, Michigan State Highway Department

Not so many years ago there was considered to be little difference in the importance of various highways. This is evidenced by the uniformity of street widths in many cities and villages where the least important side streets have the same width, as the most important thoroughfare. Further evidence is found in the fact that practically all regularly established township roads in Michigan were laid out to the uniform width of 66 ft. Notable exceptions to this are the early territorial roads which were laid out to the width of 99 ft., but even they were afterward permitted to be encroached upon until the width was generally reduced to that of ordinary township roads. Since the advent of the motor vehicle, however, traffic conditions have been revolutionized and it is now recognized that there is a vast difference in the importance of different highways.

Divisions of Highways.—The most important highways of the state, the great thoroughfares of metropolitan districts have been aptly called super-highways. Other highways of state-wide importance, the great tourist routes, those highways connecting distant centers of population, and those highways connecting cities with resort districts may be considered to comprise the primary road system. Other highways may be considered of secondary importance while still others are purely local roads. The highways of the state, therefore, fall into four divisions:

(1) Super-highways.
(2) Primary highways.
(3) Secondary highways.
(4) Local roads.

Each of these divisions may be separated into four classes:

(1) Rural highways.
(2) Residential streets.
(3) Business streets.
(4) Parkways.

Classification of Highways.—Within each division there is wide variation in the importance of different highways. A primary highway in one section of the state or nation may have less traffic than a primary highway in another section and from the standpoint of design would have less importance and therefore would require a different treatment. A secondary highway in one section may have as much traffic as a primary highway in another section. Likewise there is considerable overlapping of classes. The rural highway of yesterday may be the city or village residential street of today and may become the business street of tomorrow. We are not only confronted with these variation today but we must anticipate future changes in conditions due to increase in population, increase in the use of the highway per unit of population and development of the abutting property.

Factors to Be Considered.—In a study of highway design to correlate right of way, roadbed and slab widths for maximum utility of highways it is necessary to take into consideration many factors, among which might be listed the following:

(1) The division, whether super-highway, primary, secondary or local highway.
(2) The future class, whether rural, residential, business or parkway.
(3) Kind and amount of present traffic.
(4) Kind and amount of anticipated future traffic.
(5) Geographical location with special reference to snowfall as affecting winter maintenance.
(6) Local conditions as affected by the location of streams, lakes, views, natural tree and shrub growth and public lands.

Having considered the many factors affecting any particular road or street the problem resolves itself into the adoption of a design which will meet the three major requirements of a highway. (1) Utility. (2) Safety. (3) Attractive Appearance. The chosen design should not only meet these requirements at present but should meet them as well in the future. It is clear that the objects in view merit study by the engineer, first from the broad standpoint of meeting future requirements, and secondly from the standpoint of details to meet present requirements, but the major requirements should not be lost sight of in working out the details.

Width of Right of Way.—Perhaps the most important item to determine in the design of a highway is the width of right of way. Right of way lines govern the development of abutting property and either permit, hinder or prevent further widening of the roadway to meet future traffic conditions. Before extensive improvements of the abutting property take place right of way is generally not difficult to obtain, but after such improvements are made additional right of way is expensive, it becomes necessary to wreck, move or reconstruct buildings, sometimes at great expense, while at other times the widening is deferred until the conditions become so acute that the widening is forced at still greater expense. It is evident that the question of right of way is important, that it should be settled as early as possible for the purpose of controlling the development of abutting property and that it should be of such width that future widening of the right of way will not be necessary. To determine the proper width of right of way it is necessary to consider future

traffic conditions. While it is not necessary at present to provide for future requirements it is essential to secure the proper width of right of way and to so construct the pavement slab as to permit future widening as traffic conditions require.

Highway Requirements. — The requirements of a highway today are considerably greater than a half century or more ago. The requirements of the rural highway before the motor vehicle age were largely limited to providing space for moving vehicles with enough width to permit two vehicles to pass. Today the highway must provide space for moving vehicles, space for parking outside of the traffic lanes, space for ditches and drainage structures, foot paths, underground utilities, overhead utilities, trees and shrubs.

A passenger car is approximately 6 ft. wide and a bus or truck approaches 8 ft. in width. In order to provide for reasonably safe traffic a moving vehicle lane should be 10 ft. wide except perhaps on local highways where a 9-ft. width might suffice. While a passenger vehicle is narrower than the bus or truck, its greater speed demands more space, so that the width of 10 ft. is consistent for all classes of trunk line highway traffic. There should be space on any highway for two vehicles to pass at any point and this requires a minimum of two traffic lanes or 20 ft. In addition, space should be provided for parking on either side. Where parking is scattered as on a rural highway or residential street a width of 8 ft. for parking is satisfactory but in sections where parking is more extensive as in business districts more width, up to 12 ft., is advantageous to permit easier maneuvering into and out of the parking space. Wherever future widening of the pavement is anticipated, and this applies on primary highways generally and on secondary highways frequently, it is very desirable to make the paved parking space of the same width as the standard traffic lane so that when widening is required the former parking space may become a traffic lane and a new parking space provided.

On all rural highways space must be provided for drainage in open ditches varying in width from 6 ft. up. Foot paths along rural highways and sidewalks on residential streets require a width of approximately 6 ft. Sidewalks in business districts require a width of approximately 20 ft., although local conditions might justify some variation from these widths. Water mains, sanitary sewers, storm sewers, electric conduits, telephone conduits, gas mains, pipe lines, steam lines and other utilities require space within the right of way and, while these structures are placed underground, they should be considered in the design and space provided for them. Our statues provide for the placing of telephone, telegraph and electric power lines within the highways. The use of these utilities is increasing and even though such pole lines do not now exist on certain highways, sufficient space should be allowed to permit the proper placing of such lines whenever the conditions demand them. In order that power lines and signal lines may be kept on opposite sides of the road a 10-ft. space should be allowed on each side of the highway for such lines.

A public highway should be attractive and for this purpose space should be provided for the planting and preservation of trees and shrubs. In general, tree planting should be done in the outer portion of the right of way, or in positions where there is the least likelihood of future disturbance on account of other improvements. Shade trees require many years to develop; their span of life should cover many changes in roadway requirements and as they cannot be moved at will it is important that their position be well chosen.

Correlating Highway and Electric Railway.—On some streets and highways, particularly on some of the so-called super-highways electric railways are now existing or are anticipated in the future. To correlate highway traffic and electric railway traffic on the surface involves some serious problems and a special design. Where high speed traffic obtains the electric railway tracks should be kept entirely separated from the motor vehicle lanes by curbs while at intersections where necessary to cross such tracks at grade the electric railway traffic must be subject to the same regulations as highway traffic. This would interfere with high speed of electric railway service on the surface of public highways except through the construction of grade separations at all intersections, entailing great expense for the structure themselves combined with abuttal damages.

To secure maximum utility of our highways means to provide for traffic in winter as well as in summer, which requires snow removal. Especially in northern sections where the snowfall is heavy and cumulative the greatest aid toward snow removal is to control the drifting of snow. The least expensive and probably the most effective means of accomplishing this is through the agency of natural snow barriers formed by existing tree and shrub growth or the planting of such material. The greater the width of such barriers the more effective they are in preventing snow drifts. Right of way widths greater than necessary for other purposes are required for this means of snow drift prevention and on all trunkline highways in the snow belt the right of way width should be from 150 ft. to 200 ft. or even more except in municipalities or built-up communities.

Suggested Widths.—While it is recognized that varying conditions would affect the space required for some of the elements of the highway cross section and that the ultimate right of way widths would be correspondingly affected it is believed that the following widths would reasonably meet the requirements of the several types of highways under consideration.

Local roads, limited to two lanes for moving vehicles plus parking—66 ft. to 86 ft.

Primary and secondary highways in rural districts of the "Snow Belt"—150 ft. to 300 ft.

Primary and secondary trunklines in municipalities or built-up communities within the "Snow Belt" and quite generally outside the "Snow Belt," limited to 4 lanes for moving vehicles plus parking—100 ft.

Special primary highways limited to 6 lanes for moving vehicles plus parking —120 ft.

Super highways with provision for surface electric railway tracks combined with 8 lanes for moving vehicles —200 ft.

Super-highways with provision for high speed motor traffic separate from local traffic, a total of 10 lanes for moving vehicles—200 ft.

Except in the case of local roads the portion of the pavement slab for moving vehicles, either present or future, should be designed in units 10 ft. wide and in the case of concrete roads these divisions should be built into the pavement by means of longitudinal construction joints, which would serve as traffic guides to mark the boundaries of the traffic lanes. The ultimate parking lane for residential districts, however, could well be made 8 ft. in width to provide more space for tree planting outside of the curbs. This would then permit widening the pavement to meet future traffic conditions up to the pre-determined capacity of the highway by adding to the former construction rather than by a reconstruction of the entire roadway. Reconstruction would largely be limited to the replacement of curbs and readjustment of drainage facilities. Based on securing the proper ultimate width of right of way at the time of the first improvement, no additional right of way would be required for widening the roadway and the maximum utility of the highway would be assured at the least expense.

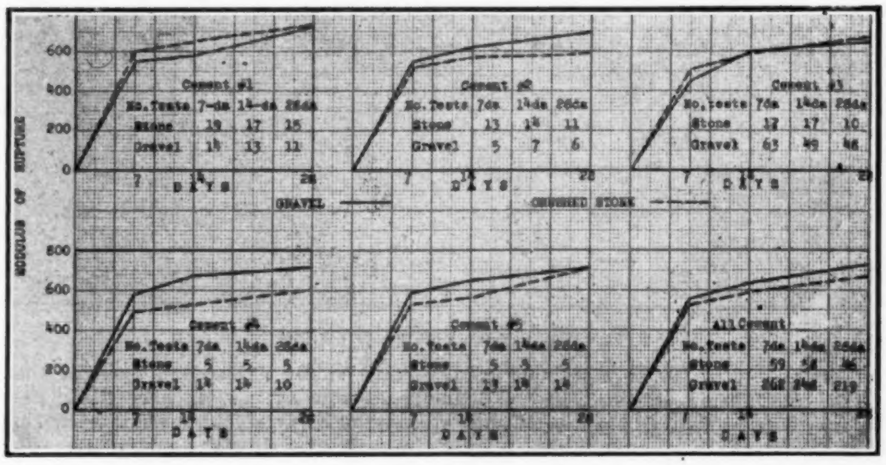
Acknowledgment.—The above paper was presented at the 49th annual convention of the Michigan Engineering Society.

Quebec, Canada, to Widen Streets.—The Quebec Legislature has authorized a loan of $2,924,700 to the city of Quebec, to be expended in widening certain streets and thoroughfares. This work will extend over a long period, and when completed will greatly facilitate traffic movement and expansion in the city. Details regarding this work are in the hands of the Administrative Committee of the City Council, City Hall, Quebec, Que.

The Effect of Recent Mix Design and Control Upon Field Concrete

Results of Studies by the Michigan State Highway Department

By CLIFFORD E. FOSTER
Chief Engineer, Michigan State Highway Department



Modulus of Rupture Tests Made on 6 in. x 8 in. x 40 in. Beams. Cement Contents 6 Sacks Per Cubic Yard

DURING the construction season of 1928, the Michigan State Highway Department changed from the volumetric method of proportioning aggregate for concrete paving mixtures to that of weighing the fine and coarse aggregates. This action was taken because it had been demonstrated, first in Iowa, and later in other states, that the weighing of aggregates was entirely practical and admittedly more accurate than volumetric proportioning.

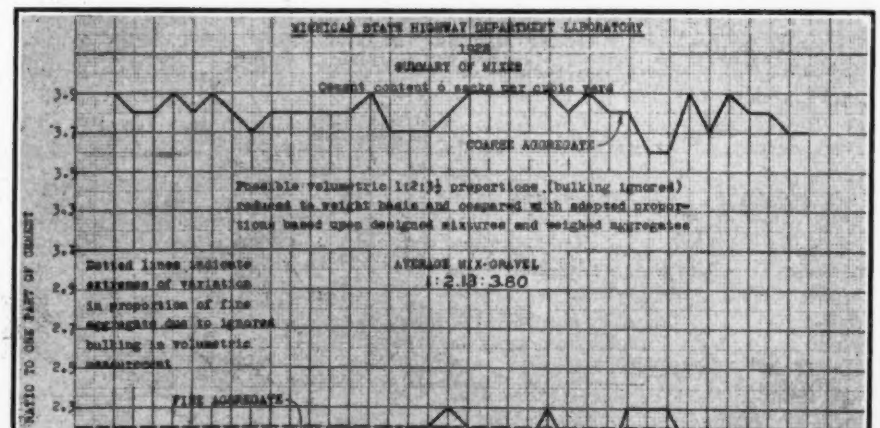
Quality Varied Widely.—From our study of core drill records and from observation of the behavior of our pavements and concrete structures in service, it was learned that the quality of concrete obtained in previous years varied widely over the state as a whole. In fact, the data indicated that uniform quality could not be depended upon, even on single projects. This was due, not to any lack of conscientious effort to secure good results, but from inherent weakness in the method of design and control of concrete mixtures then in use throughout the country at large.

In looking to the probable causes of lack of uniformity, it became apparent that there were several factors which have a very decided effect upon the strength of the concrete, of which the method of measuring the aggregates was only one.

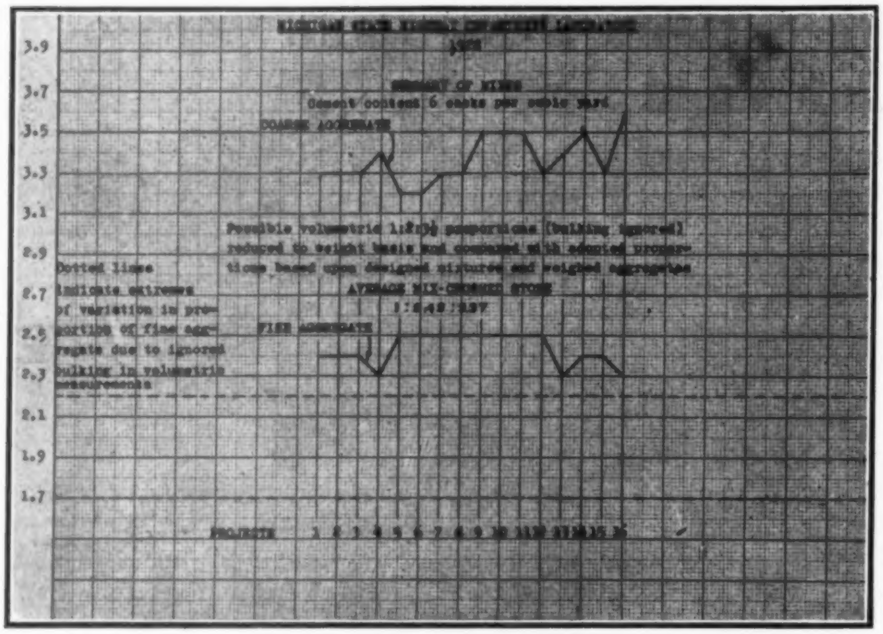
Producing Maximum Possible Strength.—Any mix proportion such as 1:2:3½ is at best an arbitrary ratio which is specified because tests have shown that in general it will produce a 3,000-lb. concrete in 28 days—provided good aggregates are used and ordinary good practice of mixing and placing is followed. No account is usually taken, under a specification of this kind, of the possibility of the most effective combination of the ingredients without distributing, in any way, the unit cement content or cost per cubic yard. But there certainly is a combination of the cement, water, fine aggregate and coarse aggregate which, with proper workability, will produce the maximum strength possible for the particular materials furnished for the work. The arbitrary specification of set proportion might produce maximum strength but most likely will not do so. Therefore the conversion of the volumetric ratio of 1:2:3½ to the same ratio by weight, leaves much to be desired in the way of quality improvement—although it must be said that this procedure will undoubtedly increase the uniformity of the results be they good, medium or poor. So it naturally follows that for the best results, each mix must be designed for the most effective combination of the materials available. This, of course, involves careful laboratory work for each job and close control of field operation.

The Mix.—The mix may be designed either for a specified strength or a maximum strength for a given cement content per cubic yard of concrete. In view of the fact that it seemed desirable to learn just what field strengths of concrete were obtainable by careful design and control, it was decided to adopt the latter method for the first year's work.

From past experience it was evident that, under most conditions, the cement content of the 1:2:3½ specification, i. e. 1.54 bbl. per cubic yard, would produce a good quality concrete. The cement content for 1928 weight jobs was



Summary of Mixes of Coarse Aggregate are Fine Aggregate



Summary of Mixes on 16 Projects

therefore fixed at 6 sacks per cubic yard and all mix designs based on that figure for the express purpose of studying the strength range obtained by field tests on the resulting concrete.

Before placing the method in operation all technical personnel having to do with paving work was given a short course in the laboratory procedure. The project engineers were equipped with the necessary apparatus for testing for moisture content and unit weight of materials. They were also furnished with a transverse beam testing machine and standard weights for testing the contractor's weighing devices. The proportioning and testing work was conducted under the direction of the laboratory and the work in the field was supervised by an inspector of paving mixtures who was thoroughly familiar with the method of design and who visited each job several times during the season to observe the results obtained and to see that the proper procedure was followed.

The modulus of rupture of sample beams taken from the pavement concrete as the work progressed was carefully determined and reported to the laboratory. The data thus obtained furnished a means of studying the results obtained. The results have been reduced to graphs and charts from which a number of conclusions may be drawn and which follow.

Weight Method Produces More Uniform Concrete.—The weight method of measuring aggregate produces more uniform concrete than the volumetric method of proportioning. This is shown by the data presented covering the overrun and underrun of cement on typical projects on which the fine and coarse aggregate was measured by these methods. The quantities of each aggregate can be more readily adjusted by weight than is possible by volume since the matter of adjusting quantities when measuring by weight is simply a case of resetting the weights on the scale beams. In the case of volumetric proportioning, in order to correct the proportions accurately, it is necessary to calibrate the containers and make considerable computation before making adjustment. The ease of making adjustment by weight is further borne out by the records on various projects where reports show that the mix was adjusted day by day to correct for moisture and variation in the coarse aggregate.

Travel Aggregate Produces Higher Modulus of Rupture.—The average results of the field tests show that gravel aggregate produces a higher modulus of rupture than crushed stone aggregate when the designs for these two coarse aggregates are based on the same yield per sack of cement and with the same provision for excess mortar. The apparent reason for the greater strength secured in case of gravel aggregate is because the crushed stone furnished under our specifications contains a larger percentage of voids than the gravel, consequently more mortar is required to fill the voids and provide an excess for workability for crushed stone than is required for gravel. It therefore follows that the ratio of sand to cement in the case of crushed stone is greater than in the case of gravel. Expressed in other words, the mortar for gravel aggregate is richer than that for crushed stone. It is a well established fact that the richer the mortar, the greater the strength, all other things being equal. The relation between the proportions for crushed stone aggregate and gravel aggregate on the past year's work was as follows:

For gravel coarse aggregate the proportions were: One part of cement to 2.13 parts of fine aggregate to 3.80 parts of coarse aggregate.

For crushed stone coarse aggregate the proportions were: One part of cement to 2.43 parts of fine aggregate to 3.37 parts of coarse aggregate.

These proportions were the average of 36 jobs where gravel coarse aggregate was used and 16 jobs where crushed stone coarse aggregate was used. It can be readily seen that the sand cement ratio in the case of crushed stone is considerably higher than that in the case of gravel. If by properly

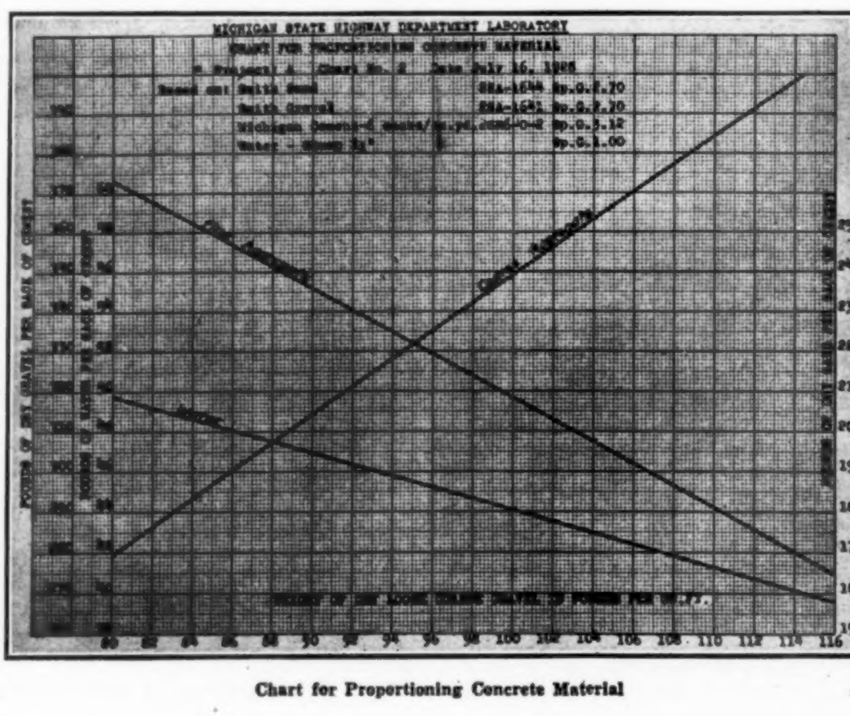
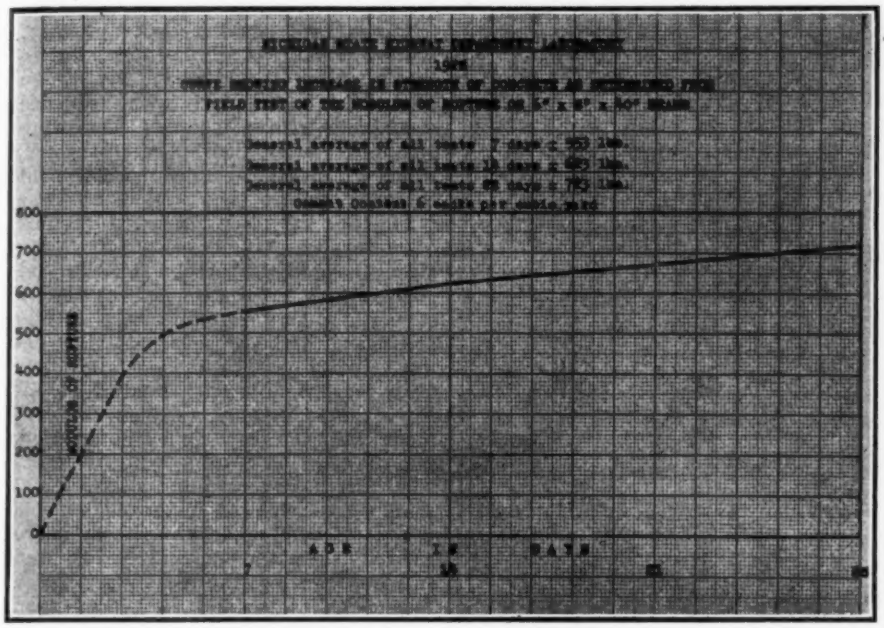


Chart for Proportioning Concrete Material



Curve Showing Increase in Strength of Concrete as Determined from Field Test of the Modulus of Rupture on 6 in. x 8 in. x 40 in. Beams

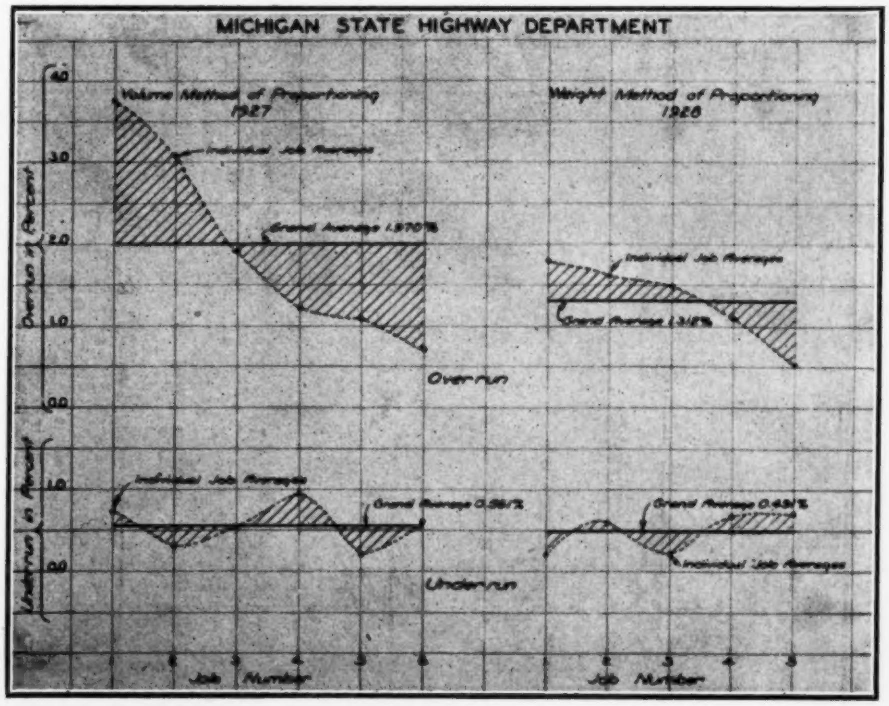
grading, the voids in the crushed stone aggregate can be reduced to the void content in the gravel aggregate, there is no apparent reason why the modulus of rupture for concrete made from crushed stone cannot be made to at least equal the strength of concrete made from gravel.

Modulus of Rupture Function of Tensile Strength.—One of the most interesting and valuable results of the study of the field specimens is the fact that, on the average, the modulus of rupture of concrete beams is a function of the tensile strength of cement. The greater the tensile strength of cement, the higher the modulus of rupture. It therefore follows that in designing concrete mixes more consideration should be given to the quality of cement than has formerly been given. This point is given emphasis by the fact that from the chart presented showing this relation, a difference of 100 lb. in tensile strength of the cement will make from 115 to 150 lb. difference in the modulus of rupture of the concrete. Since the average modulus of rupture at 28 days varied, on the jobs studied, from approximately 500 lb. to 840 lb., it may be seen that the effect of a 100 lb. difference in tensile strength of cement might effect the modulus of rupture from 15 to 30 per cent. This indicates that the quality of cement is one of the most important factors to consider in the design of a concrete mix. It may be further deduced that, when doing preliminary laboratory work in the design of a mix for a specific project, samples of the cement to be furnished to the job as well as fine and coarse aggregate should be used. The designer, in determining the proportions of the mix, may take advantage of the quality of cement which will be used on the project providing the strength record of that particular brand is known. The design, of course, must be based upon the minimum strength developed by the particular brand. Economy of design will be effected if the cement which is furnished has a high minimum strength value. It may be that a particular brand of cement has a high average strength value, however this value should not be used in design.

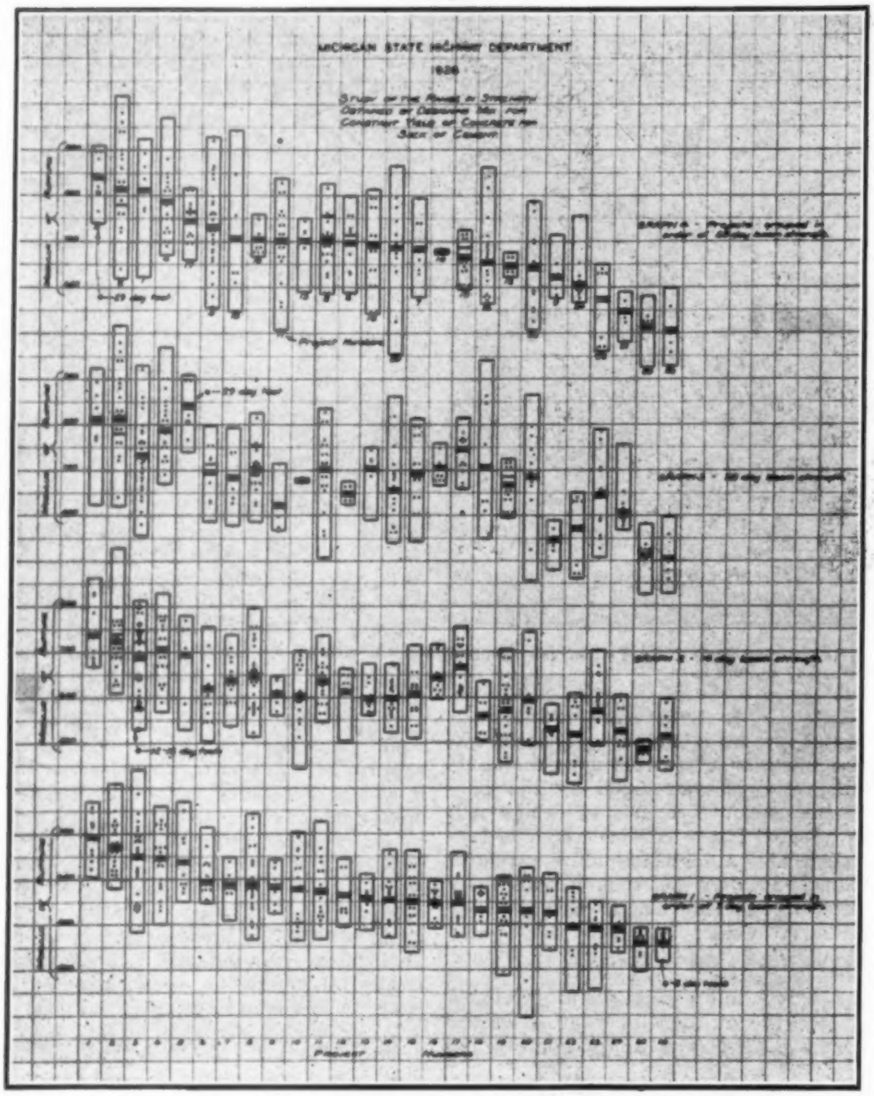
Another interesting point developed is that the modulus of rupture of the beams studied was approximately 180 per cent of the tensile strength of the cement briquettes of the same age. This, of course, is an average result, but it furnishes an approximate index of what may be expected for concrete containing six sacks per cubic yard, using materials available in our state for fine and coarse aggregate.

Design Strength Adopted.—As previously stated the design of the various mixes during the past year was based on securing the great strength possible from 6 sacks of cement per cubic yard in combination with the various materials furnished on our projects. From the data secured it has been learned that the average 28 day modulus of rupture was slightly over 700 lb. The chart showing the projects grouped in order of their 28 day strength shows a range of modulus of rupture from 500 to 840 lb. The chart shows further that on a large number of projects, the 28 day average modulus of rupture was very close to 700 lb. A modulus of rupture of 700 lb. therefore appears to be about the strength which could be used for design with approximately the same cost for cement as under the present system of designing for constant yield. In adopting a modulus of rupture of 700 lb. for design strength, it will be necessary to increase the cement content on some projects in order to secure the design strength. On other projects it will be possible to reduce the cement content. It appears from the data available that the increase in cement content on those projects, where an increase is necessary, will be practically off-set by the decrease on those projects where a decrease is possible.

In view of these facts it has been



Effect of Method of Proportioning on Overrun and Underun Curves Showing Relation of Modulus of Rupture at 7, 14 and 28 Days Between Two Coarse Aggregates, Gravel and Crushed Stone.



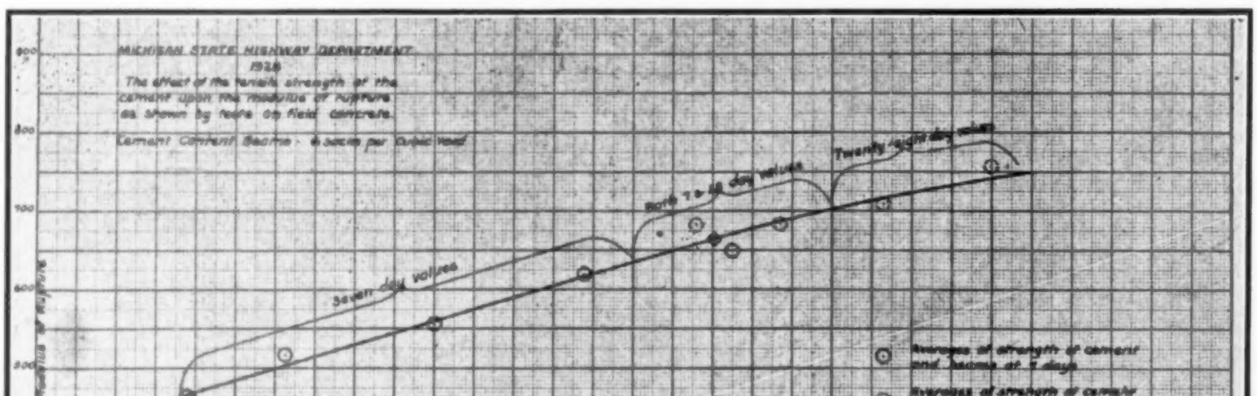
Study of Range of Strength Obtained by Designing Mix for Constant Yield of Concrete Per Sack of Cement

decided to design our concrete paving mixtures for a modulus of rupture of 700 lb. at 28 days. It is interesting to note that, on the average, the design worked out on this basis should produce a concrete with a modulus of rupture of approximately 550 lb. in seven days, which will permit opening the pavement to traffic within that period. It was found that the 14-day average modulus of rupture was 112 per cent of the 7-day strength and the 28-day modulus of rupture was 124 per cent of the 28-day strength, but an examination of results secured with the various brands of cement indicates that these percentages vary for the different brands. Therefore, the arbitrary opening of pavements at seven days cannot be adopted, but the time of opening will, of necessity, have to be controlling by the actual testing of specimens in the field. This program will necessitate even more careful design and control than has been in effect during the past year. Too much emphasis cannot be placed upon the desirability of accurately controlling all operations if more than average results are to be expected.

Acknowledgment.—The foregoing paper was presented Feb. 21 at the 15th annual conference on highway engineering at the University of Michigan.

Location Crew Makes Record in New Mexico

A location crew working under the State Highway Department of New Mexico has recently hung up a mark which is believed to be a Southwestern record. The crew turned in a report of 15 miles of completed survey in ten days working time. This includes cross sections, topography, drainage areas, and all the perquisites of a completed road survey.



Effect of Tensile Strength of the Cement Upon the Modulus of Rupture as Shown by Tests on Field Concrete

The Practical Utility of Highway Transport Surveys

Their Application to Studies for Toll Bridges

By N. W. DOUGHERTY
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HIGHWAY transport surveys have a special value in connection with the construction of highway bridges that are to be financed by toll charges. In 1927, the state legislature of Tennessee authorized the construction of 16 toll bridges. The legislation comprises three acts, each providing for a series of bridges to be considered as a unit and to be financed by the issuance of bonds, which, in turn, are to be retired by the income from tolls.

The bridges in the first group are needed and the tolls will easily finance their construction and maintenance. The bridges of the second group are in isolated areas and on secondary highways and it is doubtful whether any of them will prove paying investments. As a whole, this series will be difficult to finance from the tolls collected. The acts authorizing these two groups also fixed the charges that will be made, thus fixing the income which the highway department may reasonably expect from the structures. Had studies of income been made before the legislation was enacted, several of the structures would not have been authorized because it would be cheaper to operate ferries without charge. The bridges of the third series will serve a real traffic need and at least two of them will finance themselves. It is probably that the two profitable bridges will finance the third.

All the bridges in each group were classed together, and were to be paid for out of the tolls, the group to be made free as soon as the bonds on the whole series were retired.

Estimate of Traffic.—The State Highway Department of Tennessee has been conducting studies for a period of years in order to determine the relation between the average flow and the seasonal flow of traffic as well as the volume of traffic that may be reasonably expected over the proposed bridges. The data show that the traffic in August is approximately 33 per cent more than the average for the year. The total 24-hour traffic is 133 per cent of the daylight flow. This was determined by taking night counts. A 12-hour count taken in August, therefore, approximates the average 24-hour flow throughout the year. In 1926 a general count was made throughout the state, and this is used as a basis for predicting future travel.

In Tennessee, as in other states, the increase in traffic flow has been approximately proportional to that of motor vehicle registration. This has been used as a basis of foretelling the volume of future traffic. Predictions made about 1923 have agreed fairly well with the actual registration for 1926 and 1927.

A more accurate value may be determined if the many sources are estimated separately. A study of vehicle license numbers from the several sections of the state has shown that the preponderance of travel is from the county in which the road is located or from the adjoining counties. The study was divided, therefore, into (a) Local travel; (b) travel from counties of large registration; (c) travel from other counties of the state; and (d)

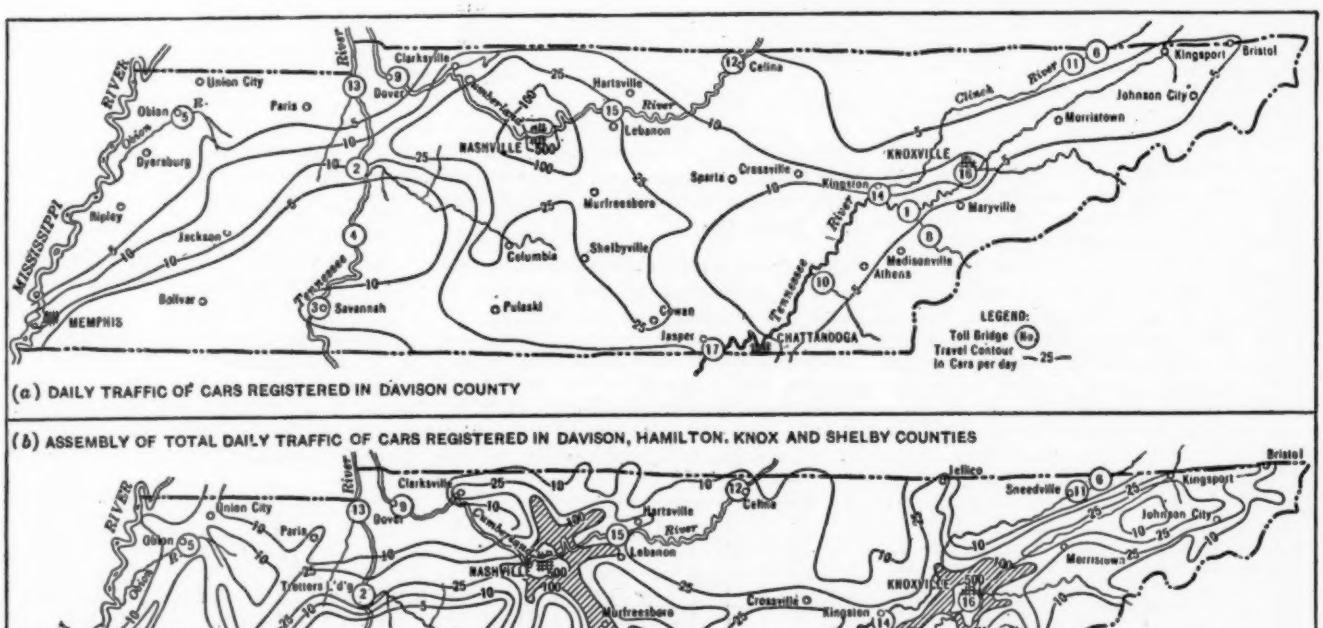


Fig. 1—Traffic Map of Tennessee for 1928 Showing Location of Toll Bridges and Traffic Contour in Cars Per Day

travel from other states. No effort is made to separate the truck flow from the travel of automobiles, on the assumption that the same law applies for the trucks as for the passenger car.

Local Travel.—To estimate local travel, a large number of stations were selected at which the flow of vehicles was obstructed as little as possible. It is well known that detours, bad stretches of road, construction under way, and other obstructions, limit the free flow of vehicles. From preceding counts an estimate was made of the flow of local vehicles at the stations. From records of motor-vehicle registration, an estimate was made of tributary motor vehicles by assuming that they would pass the station in proportion to their remoteness considering only the counties in tributary areas. In other words, of the total cars registered in the various counties, a certain percentage will contribute potentially to the daily traffic density at a fixed observation station. The writer has estimated this percentage as some ratio of the relative distances or remoteness from the observation station.

A typical analysis is shown in Table I for the station at Spring Hill, Tenn., near the Williamson-Maury County line. The percentage in column (2) varied with the distance from Spring Hill and from a knowledge of the topography in the area.

The local travel at Spring Hill in 1926 was 573 vehicles per 12-hour day, which was a ratio of travel to weighed registration of 0.091. If two main thoroughfares are parallel across a county, certain vehicles will be tributary to one highway and others will flow over the other highway. About twenty stations were studied in a similar way, and it was found that the weighted motor-vehicle registration was ten times the local travel at the stations.

It is assumed, therefore, that the travel at other unobstructed stations will be approximately one-tenth the tributary motor-vehicle registration (see Table II). An estimate was then made of the motor-vehicle registration tributary to all the proposed bridge sites. This was done by projecting the curve of registration from 1920, through 1927, to 1940. Many factors cause the registration to change, but all of them can hardly be estimated in advance. The trend of the preceding seven years was probably the best information at hand and was therefore used in the

Table I—Estimated Number of Registered Vehicles that Contribute to Traffic Density at Spring Hill Station

County. (1)	Percentage of total cars registered that contribute to traffic. (2)	Cars registered in county. (3)	Weighted values. (4)
Williamson	80	2,908	2,326
Maury	60	3.164	1,898
Giles	30	2,655	797
Lawrence	30	2,315	695
Marshall	20	1,917	233
Hickman	10	1,115	112
Lewis	10	644	64
Total			6,175

Table II—Estimated Ratio Between Number of Cars Passing a Station and Total Cars Registered in the District Served

Route.	Location.	Cars registered.	Number of cars counted.	Ratio.
1	Bloutville	6,900	692	0.100
24	Overtown County Line	2,150	210	.097
1	West of Crossville	2,130	230	.108
6	Spring Hill	6,275	573	.091
3	Ripley	6,220	685	.110
28	Dunlop	1,340	149	.104
16	East of Shelbyville	6,125	613	.099
64	One mile south of Madisonville	1,200	60	.050
34	Seven miles west of Morristown	3,400	350	.103
1	Church Hill	4,300	500	.125
10	Ten miles south of Murfreesboro	4,160	500	.120
52	Macon County	2,400	280	.115
1	McEwen	3,400	350	.103
6	Near Franklin	5,500	600	.110
76	Seven miles south of Clarksville	2,300	175	.075
3	South of Union City	4.500	360	.080
42	Modina	5,000	360	.072
1	Huntingdon	7,000	610	.087
	Totals, or average	74,360	7,289	0.97

study. The population was estimated from the census reports and the registration was taken from the records of the Department of Finance and Taxation through 1927.

The weighted value taken is that obtained by assuming that the percentage of the cars tributary to the station varied with the distance from the source of the station. Some of the percentages are somewhat arbitrary and were determined from a personal knowledge of the topography and characteristics of the sites.

A typical analysis is given in Table III for Route 15 at the bridge over the Tennessee River between Waynesboro and Selmer, Tenn. (Bridge 3, Fig. 1).

Table III—Typical Analysis of Population Traffic at the Bridge at Savannah, Hardin County, Tenn.

County.	Percentage of total registration effective.	Population 1910.	Population 1920.	Estimated Population that Contributes to Traffic at the Savannah Bridge. 1910.	Estimated Population that Contributes to Traffic at the Savannah Bridge. 1910.
Hardin	90	17,521	17,291	15,769	15,562
McNairy	70	16,356	18,350	11,449	12,845
Wayne	50	12,062	12,877	6,031	6,439
Lawrence	10	17,569	23,593	1,757	2,359
Chester	10	9,090	9,669	909	967
Hardeman	10	23,011	22,278	2,301	2,228
Total	....	....	....	38,216	40,400
Increase in 10 years..	....	....	....	....	2,184

Weighted registrations were obtained in a similar manner, using the actual registrations for each county each year (see Table IV).

The local unobstructed travel, therefore, is estimated at 340 vehicles in 1930, 385 in 1935, and 400 in 1940.

Large Cities.—The four large cities contain 48.5 per cent of the motor vehicles registered in the state. It is desirable, therefore, to study the effect of motor-vehicle concentration in the large cities. Fortunately, information was available for this study. During the 1926 count, automobile license numbers were listed at more than 40 stations. From the records in the Bureau of Registration, the location of ownership was determined and a tabulation was made for Davidson, Knox, Hamilton, and Shelby Counties, which include the cities of Nashville, Knoxville, Chattanooga, and Memphis, respectively. Fig. 1 (a) shows by contour the number of cars per day originating in Davison County as they traveled throughout the State of Tennessee in 1926. The composite map (Fig. 1 (b)) shows the effect of nearly 50 per cent of the automobiles of the state on the travel at the several bridge sites.

By projecting the registration for the four large counties forward to 1930 and 1940, an estimate may be made of the probable travel over the several bridges from this source.

Bridge No. 1 at London, for example, is between Knoxville and Chattanooga, on the primary system (Fig. 1) and a large flow may be expected. Bridge No. 6, at Kyles Ford, is not on the primary system; it lies in a remote

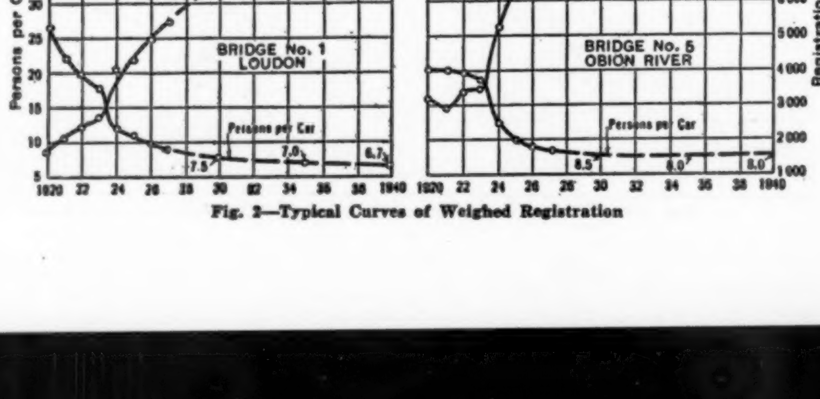


Fig. 2—Typical Curves of Weighed Registration

section of the state and, consequently, serves very few vehicles from the large counties.

The travel from other counties not included in the local and large cities has been assumed arbitrarily as 50 per cent of that from the counties of large registration. The registration for the four counties is projected into the future so as to give an estimate for 1930, 1935 and 1940 (Table IV).

Figure 2, which is typical of the studies made, shows a steady decrease in rate of registration. This is explained by the fact that, at present, there is one motor vehicle to each 5.4 persons in these counties. It is probable that the density will not increase to much more than 1 motor vehicle to 4.5 persons. Some states have a denser registration, but they also have a greater wealth per capita than Tennessee. The average wealth of the United States is double that of Tennessee. In Fig. 2, the registration is the weighted value, derived by estimating the percentage of total cars registered throughout the State that may be expected to influence traffic density at the observation station under discussion.

Foreign Travel.—On the main thoroughfares crossing the State there has been a marked increase in outside State travel since about 1926. This increase will continue as the highways are improved, but it is difficult, if not impossible, to estimate the future rate. The amounts entered in Table V are based on the present flow, modified by a knowledge of previous increase and by the location of the several bridge sites. For example, at Savannah (Bridge No. 3, Fig. 1), it is assumed that the travel will increase greatly in the near future because of the attraction of Shiloh National Park, and because of the improvement of state highways in this area.

Charges at Bridges.—The law provided a schedule of tolls at each of the structures in Series No. 1 as listed in Table VI. From traffic information taken at each of the bridges, a weighted charge per motor vehicle is computed. The estimate of future traffic is based on motor-vehicle registration, and, consequently, the income is based on motor vehicles alone. At each of the sites a few horse-drawn vehicles still use the highways. There is a varying distribution of light and heavy trucks, depending on the location. At each bridge an estimate of income has been made from actual travel, according to the schedule of the tolls listed in Table VI, and from this estimate the average charge per motor vehicle is made. The Tennessee cars are kept separate from the foreign cars because the percentage of trucks from outside the State is very small. The average charge for Tennessee motor vehicles is obtained by dividing the total receipts for the day by the total motor vehicles passing the station. The charge for foreign automobiles is obtained by adding to the amount received for the automobiles, one and one-half times 5 ct.; making the charge for Bridges Nos. 2, 3 and 4, equal to 57.5 ct.; and for Bridges Nos. 1, 5, 6 and 8, a charge of 32.5 ct. A sample computation is given for the London Bridge (No. 1, Fig. 1), as follows:

Automobiles	640 × \$0.25 =	\$160.00
Passengers	1,300 × 0.05 =	65.00
Light trucks	32 × 0.25 =	8.00
Heavy trucks	35 × 0.50 =	17.50
Trailers	1 × 0.25 =	0.25
Horse-drawn	1 × 0.15 =	0.15
Horse-drawn	5 × 0.10 =	0.50
640 + 32 + 35 = 707 vehicles =		\$251.40
707 × 35.5 + =		251.40
\$0.25 + 5 × \$0.015 =		\$0.325

The average number of passengers per car in Tennessee, as shown by previous counts, is 2.5 persons per car. Data taken at the ferries indicate a similar number of passengers. An automobile, therefore, will pay 25 ct. for driver and car and 5 ct. additional for each passenger.

To obtain the daily estimate tolls for 1930, 1935 and 1940, Tennessee travel is multiplied by the average charge for each station, and the foreign travel is multiplied by 32.5 ct., or 57.5 ct., according to the schedule of tolls fixed by law. The weighted charges for each bridge in Group 1 are listed in Table VII.

Expectancy.—In making an estimate of the travel at the several bridges, free flow was assumed from all the tributary area. This assumption is far from the truth for many of the bridges proposed. Some of the locations are in areas where highways will have to

Table VI—Toll Charges Specified on Bridges in Series No. 1

Item No.	Description	Bridges Nos. 2, 3 and 4	Bridges Nos. 1, 5, 6, 7 and 8
1	Automobile driver	\$0.50	\$0.25
2	Person, each	0.05	0.05
3	Motor truck or motor bus (1 ton capacity or less) and driver	0.50	0.25
4	Motor truck or motor bus (more than 1 ton capacity) and driver	1.00	0.50
5	Automobile trailer	0.25	0.15
6	Motor truck trailer or motor bus trailer	0.50	0.25
7	Motorcycle and driver	0.25	0.15
8	One-horse vehicle, with draft animal and driver	0.15	0.10
9	Two-horse vehicle and two draft animals and driver	0.25	0.15
10	Extra draft animals or horses or mules, each	0.05	0.05
11	Cattle, sheep, hogs, or other domestic animals, other than horses or mules on foot, each	0.02	0.02
12	Circus animals, other than those specifically mentioned in Items 8, 9, 10 and 11	0.25	0.25

Table VII—Weighted Toll Charges for Bridges in Group 1

Description	Charge per vehicle						
Bridge No.	1	2	3	4	5	6	8
Local	\$0.355	\$0.650	\$0.575	\$0.610	\$0.340	\$0.330	\$0.325
Foreign	0.325	0.575	0.575	0.575	0.325	0.325	0.325

Table VIII—Probable Local Traffic Flow Over Bridges in the First Series

Bridge No.*	Traffic, 1927	Estimated traffic, 1927	Expectancy, in percentage of theoretical or estimated traffic, 1927
1	717	1,000	72
2	210	425	50
3	120	300	40
4	40	150	26
5	600	750	80
6	25	125	20
8	155	325	48

*See Fig. 1

Table IV—Weighted Registration for Study of Savannah Bridge

Year.	1910.	1920.	1921.	1922.	1923.	1924.	1925.	1926.	1927.	1930.	1935.	1940.
Population	38,216	40,400	40,618	40,836	41,054	41,272	41,490	41,708	41,928	42,580	43,670	44,760
Number of cars registered	—	756	837	892	930	1,465	2,030	2,638	2,828	3,400	3,850	4,000
Persons per vehicle	—	52.5	48.5	45.5	44.0	28.0	20.3	15.9	14.8	12.5	11.6	11.2

Table V—Estimated Daily Travel on Bridges of the First Series

Territory	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 8
1930							
Local	660	415	340	205	750	134	370
Large counties	200	45	12	6	15	6	30
Other counties	100	20	6	3	8	3	15
Total, in State	960	480	358	214	773	143	415
Foreign	400	200	75	20	100	20	35
Total	1,360	680	433	234	873	163	450
Probable ratio of actual to theoretical traffic flow	80	55	50	35	90	30	60
1935							
Local	760	450	385	235	800	148	420
Large counties	220	50	14	8	20	8	35
Other counties	110	25	7	4	10	4	20
Total, in State	1,090	525	406	247	830	160	475
Foreign	600	300	150	40	250	30	60
Total	1,690	825	556	287	1,080	190	535
Probable, ratio of actual to theoretical traffic flow	90	60	60	40	......	40	70
1940							
Local	840	480	400	250	810	153	480
Large counties	230	60	15	10	25	10	40
Other counties	115	30	8	5	13	5	20
Total, in State	1,185	570	423	265	848	168	540
Foreign	750	400	250	50	400	40	80
Total	1,935	970	673	315	1,248	208	620
Probable ratio of actual to theoretical traffic flow	100	70	75	50	100	50	75

Table IX—Estimated Daily and Annual Tolls from Bridges in the First Series

Bridge	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 8
		1930					
Tolls per day:							
Tennessee cars	$ 339	$ 312	$ 205	$ 130	$ 263	$ 47	$ 185
Foreign cars	130	115	43	11	32	6	11
Total per day	469	427	248	141	295	53	146
Percentage of expectancy	80	55	50	35	90	30	60
Probable daily	$ 374	$ 235	$ 124	$ 49	$ 265	$ 16	$ 88
Annual	136,000	85,500	45.200	18,000	96,500	5,800	32,000
		1935					
Tolls per day:							
Tennessee cars	$ 386	$ 341	$ 234	$ 150	$ 282	$ 53	$ 154
Foreign cars	195	172	86	23	81	10	19
Total per day	581	513	320	173	363	63	173
Percentage of expectancy	90	60	60	40	95	35	70
Probable daily	$ 523	$ 308	$ 192	$ 69	$ 344	$ 22	$ 121
Annual	191,000	112,000	70,000	25,200	125,000	8,000	44,000
		1940					
Tolls per day:							
Tennessee cars	$ 420	$ 370	$ 243	$ 162	$ 288	$ 55	$ 175
Foreign cars	243	230	143	29	130	13	26
Total per day	663	600	386	191	418	68	201
Percentage of expectancy	100	70	75	50	100	40	75
Probable daily	$ 663	$ 420	$ 290	$ 95	$ 418	$ 27	$ 150
Annual	242,000	153,000	106,000	34,800	152,000	9,900	55,000

Table X—Estimated Annual Cost and Time Required for Retirement of Bonds on Bridges of the First Series

Bridge No.	Income 1930	Income 1935	Income 1940	Cost	Interest at 4½ per cent	Upkeep and operation	Annual cost	Time to retire cost, in years
1	$136,000	$190,000	$242,000	$ 800,000*	$ 36,000	$10,000	$ 46,000	7
2	85,500	112,000	153 000	1,014,359	45,600	10,000	55,600	13
3	45,200	70,000	106,000	850,513	38,300	10,600	48,300	15
4	18,000	25,200	34,800	727,445	32.800	10,000	42,800	Indefinite
5	96,500	125,000	152,000	214,323	9,600	9,000	18,600	3
6	5,800	8,000	9.900	62,104	2,800	5,000	7,800	25
8	32,000	44,000	55,000	155,481	7,000	5,000	12,000	6
Total	$419,000	$575,200	$752,700	$3,824,225	$172,100	$59,000	$231,100	11

*Estimated cost.

be constructed. The estimates made from the curves, therefore, are modified as nearly as may be to suit the station in question.

Traffic was counted in August, 1927, at all stations. An estimate has been made of the probable local flow from the motor-vehicle registration. Table VIII gives the actual and estimated travel for 1927 and shows the percentage that the actual travel is of the theoretical. From Table VIII and a knowledge of the particlar locations and the progress of highway improvement it is possible to derive the percentage expectancy for the several sites.

Expected Income.—Having tabulated the probable travel for 1930, 1935 and 1940, it only remains to compute the income for each year modified by the expectancy as listed in Table IV. The specified toll charges are given in Table V and simple multiplication therefore produces the result shown in Table IX.

All the bridges of this group have been let to contract. The costs for each structure and the cost for the whole group, therefore, are approximately known. The probable annual cost may be easily estimated. Table X gives the estimated annual cost and the probable period required to retire the cost of construction.

Acknowledgment.—The foregoing is a discussion in the April Proceedings of the American Society of Civil Engineers of a paper presented by G. F. Schlesinger.

Costa Rica Sells Bond Issue to Finance Road Construction.—On March 7, 1929, the Costa Rican Government sold a bond issue of $2,750,000, to provide funds for the construction of roads.

Many Unique Features in Sand and Gravel Plant

The Van Camp Sand & Gravel Co.'s new plant now being constructed for them by the Milburn Machinery Co. of Columbus, O., will be one of the largest and most modern in the United States. It is located at South Lebanon, O., near Cincinnati, and will have a capacity of 300 yd. of washed gravel per hour. The machinery is being built by the Smith Engineering Works of Milwaukee, Wis., and the third of six carloads of equipment was shipped between April 15 and 18.

Every piece of machinery in this plant will be equipped with anti-friction bearings. This marks a distinct step forward in the history of gravel plant equipment, for as far as known, it is the first time anti-friction bearings have been used throughout an entire plant's machinery. The use of anti-friction bearings is becoming so increasingly popular, however, that the makers of this equipment predict it will soon be standard practice.

The plant has many other interesting and novel features. The bins are to be in the form of nine cylindrical concrete silos, arranged in two sets, five on one side and four on the other. Two of the crushers and all the washing screens will be located on top of the bins. This equipment is to be completely housed with corrugated iron, making a considerable structure on top of the silo bins.

The Van Camp Sand & Gravel Co.'s main offices are located at 405 Palace Building, Cincinnati, O. The officers are B. T. Van Camp, president; John B. Campbell, secretary-treasurer; and John Sloan, vice-president; all Cincinnati men.

National Roads Development in Australia

According to returns made by the Federal Department of Works, since the Federal Aid Roads' agreement was entered into between the commonwealth and state governments about two years ago, approximately 4,500 miles of roads have been constructed, formed or remade in the different states with the assistance of the federal government, according to a report from the Consulate General, Melbourne, released by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce. Up to the end of 1928 approximately £3,500,000 ($16,979,375) had been spent on this work during the two years.

Three classes of road work have been carried out under this scheme, namely (1) main arterial roads, (2) trunk roads between important towns, and (3) developmental roads, being roads constructed for the opening up of new country. In the states where development is more advanced, Victoria, New South Wales, South Australia and Tasmania, 75 per cent of the money has been spent on arterial and trunk roads, and 25 per cent on developmental roads. In Queensland and Western Australia the position is reversed, 25 per cent of the money allocated having been spent on arterial and trunk roads and 75 per cent on developmental roads.

The above work has been financed out of the grant of $97,025,000 made by the commonwealth government to the states for national road work, and to which they also contribute, to be spread over a period of 10 years. The portion of this amount spent in Victoria up to the end of 1928 is about $6,306,625, and about 450 miles of roads have been made, reconstructed or improved in that state. In New South Wales the proportion is $9,402,615; in Queensland, $6,384,245; in South Australia, $3,871,297; in Western Australia, $6,520,080, and in Tasmania, $1,697,937.

Progress of Greek Road Construction in 1928.—The £6,000,000 road construction and repair contract which was awarded to a British-Greek group provided the funds for the road program started during the summer of 1928 on the basis of a £400,000 advance made by the firm which had been awarded the construction contract. The whole program is to be financed from the £22,000,000 productive loan arranged by American and British bankers. The £400,000 advance has been paid back to the construction company, a £1,000,000 has been allotted for the work to be undertaken during 1929. In addition to the roads begun by the Greek subcontractors of the concessionnaires, about 150 miles of roads were constructed or repaired during 1928 for the account of the government, at a total cost of about dios 100,000,000 ($1,295,000).

Cost Data on a 10 Mile Concrete Pavement Job Built By State Forces

A Typical Highway Job in Michigan

By M. O. HAMMER
Cost Data Engineer, Michigan State Highway Department

IN the December, 1928, issue of Roads and Streets an article was published showing the various forms used by the Michigan State Construction Division to secure our cost data.

The present article shows the use of some of these forms and contains some 1928 cost data on a concrete paving project approximately 10 miles long.

The pavement design built was the highway department's standard 20-ft. width, 7-in. center and 9-in. edges.

This project has been selected for several reasons: First, it combines both industrial and truck haul; the major portion is industrial. Second, it is a fairly large project. Third, it has two yard set-ups supplying aggregates; one for truck haul and the other for industrial haul, and fourth, it represents the average Michigan conditions.

Wages and General Conditions.—Except for skilled special labor, convict labor was used entirely. This convict labor cost the job 30 ct. per productive hour. Foremen and superintendents received from $35 to $60 per week, depending upon their work. All other labor cost the job from 40 ct. to 60 ct. per productive hour.

Paver No. 1, a 5-bag machine using a truck haul for supplying the aggregate, poured 1.81 miles with a dead haul of 4.7 miles, while paver No. 2, also a 5-bag machine, poured the remaining 8.34 miles, using a narrow gauge industrial with a dead haul of 0.25 miles. The average haul for paver No. 1 was approximately 5.6 miles, while for paver No. 2 the average haul was approximately 4.42 miles, making the average haul for the entire job approximately 4.63 miles.

All cement was trucked in to a platform in the yard from a local cement plant, while sand and coarse aggregate was shipped in by rail.

Mixer Production Comparison.—By referring to Fig. 1 we can draw a comparison between the production of the two pavers. Paver No. 1 began work on May 8 and encountered much rainy weather. This caused the average daily runs to drop and likewise caused the paving cost units to go up. On May 8 and 9 the daily runs were held back by the regulation of batches in the loading yard. All materials in batches were proportioned by weight and this needed some time to regulate. The balance of that week, fairly good runs were made. On the 14th and 15th delays occurred caused by the shortage of sand in the loading yard and the balance of this week the rainy weather prevented work. This weather continued to June 7, thereby causing con-

Paver #1

May		
8th	447 L.Ft.	
9th	481 L.Ft.	
10th	680 L.Ft.	
11th	636 L.Ft.	
12th	614 L.Ft.	
13th	Sunday	
14th	496 L.Ft.	Sand Shortage
15th	534 L.Ft.	
16th	-0-	Rain
17th	-0-	Rain
18th	-0-	Rain
19th	-0-	Rain
20th	Sunday	
21st	218 L.Ft.	Rain
22nd	809 L.Ft.	
23rd	647 L.Ft.	
24th	357 L.Ft.	Rain
25th	-0-	Rain
26th	598 L.Ft.	
27th	Sunday	
28th	636 L.Ft.	
29th	78 L.Ft.	Sand Shortage
30th	Holiday	
31st	791 Ft.	
June		
1st	542 Ft.	
2nd	635 Ft.	
3rd	Sunday	
4th	-0-	Rain
5th	-0-	Rain
6th	-0-	Rain
7th	426 L.Ft.	Finished
	9551 L.Ft.	(1.81 Miles)
Days Worked	18	
Average Run	586.2 Ft.	
Total Time	26 Days	
Average Run	367.3 Ft.	

Paver #2

May		
14th	331 L.Ft.	
15th	653 L.Ft.	
16th	-0-	Rain
17th	-0-	Rain
18th	-0-	Rain
19th	-0-	Rain
20th	Sunday	
21st	381 L.Ft.	Rain
22nd	754 L.Ft.	
23rd	748 L.Ft.	
24th	351 L.Ft.	Rain
25th	-0-	Rain
26th	651 L.Ft.	
27th	Sunday	
28th	647 L.Ft.	
29th	671 L.Ft.	
30th	Holiday	
31st	851 L.Ft.	
June		
1st	922 L.Ft.	
2nd	Moving	
3rd	Moving	
4th	Moving	Rain
5th	Moving	Rain
6th	Moving	Rain
7th	Moving	
8th	Moving	
9th	Moving	
10th	Sunday	
11th	561 L.Ft.	
12th	700 L.Ft.	
13th	653 L.Ft.	
14th	682 L.Ft.	
15th	631 L.Ft.	
16th	762 L.Ft.	
17th	Sunday	
18th	-0-	Rain
19th	12.1 L.Ft.	Rain
20th	431 L.Ft.	Rain
21st	73.7 L.Ft.	
22nd	Moving	
23rd	Moving	
24th	Sunday	
25th	710 L.Ft.	
26th	601 L.Ft.	
27th	566 L.Ft.	
28th	581 L.Ft.	
29th	-0-	Rain
30th	-0-	Rain
July		
1st	Sunday	
2nd	511 L.Ft.	
3rd	692 L.Ft.	
4th	Holiday	
5th	691 L.Ft.	
6th	661 L.Ft.	
7th	633 L.Ft.	
8th	Sunday	
9th	451 L.Ft.	Rain
10th	653 L.Ft.	
11th	-0-	Rain
12th	700 L.Ft.	
13th	522 L.Ft.	Rain
14th	310 L.Ft.	Rain
15th	Sunday	
16th	601 L.Ft.	
17th	609 L.Ft.	
18th	719 L.Ft.	
19th	522 L.Ft.	Rain
20th	-0-	Rain
21st	291 L.Ft.	Rain
22nd	Sunday	
23rd	-0-	Rain
24th	702 L.Ft.	
July		
25th	751 L.Ft.	
26th	641 L.Ft.	
27th	340 L.Ft.	Rain
28th	-0-	Rain
29th	Sunday	
30th	621 L.Ft.	
31st	784 L.Ft.	
August		
1st	760 L.Ft.	
2nd	635 L.Ft.	
3rd	652 L.Ft.	
4th	680 L.Ft.	
5th	Sunday	
6th	663 L.Ft.	
7th	761 L.Ft.	
8th	672 L.Ft.	
9th	731 L.Ft.	
10th	734 L.Ft.	
11th	662 L.Ft.	
12th	Sunday	
13th	602 L.Ft.	
14th	560 L.Ft.	
15th	672 L.Ft.	
16th	661 L.Ft.	
17th	643 L.Ft.	
18th	641 L.Ft.	
19th	Sunday	
20th	712 L.Ft.	
21st	512 L.Ft.	
22nd	761 L.Ft.	
23rd	622 L.Ft.	
24th	330 L.Ft.	Rain
25th	640 L.Ft.	
26th	340 L.Ft.	Sunday
27th	Moving	
28th	508 L.Ft.	
29th	619 L.Ft.	Finished
	44044 L.Ft.	(8.34 Miles)
Days Worked	70	
Average Run	629.2 L.Ft.	
Total Time	93 Days	
Average Run	473.6 L.Ft.	

Fig. 1.—Comparison Between the Production of the Two Mixers

siderable expense against the small runs made each day.

Paver No. 2 began on May 14 and also experienced many delays due to rainy weather, but from June 11 to August 29 good weather conditions prevailed and this paver maintained a very good pace, as can be seen from Fig. 1. This steady pace resulted in lower unit costs for the various operations connected with this paver than with those of paver No. 1.

Cost Comparison.—Figure 2 gives a comparison between the cost of various operations of work connected with each paving unit. These operations shown in Fig. 2 are:

A. Moving in equipment includes such cost items as labor, gasoline, oils, equipment rental, freight, cartage, etc., connected with moving in the paving equipment. This covers all equipment, except the loading yard equipment, which is carried under item "L."

B. Trenching: This covers all expense connected with trucking, such as labor, supplies and equipment rentals.

C. Water lines cover all expense connected with the laying, maintaining, operating of pipe lines, pumps, etc., also the taking up of this equipment when the project was completed.

D. Forms cover all costs of setting, transporting and cleaning of forms.

E. Truck haul (aggregates) covers all expense connected with hauling aggregates and other materials by trucks, such as labor, supplies, equipment rentals, etc.

F. Industrial haul (aggregates) covers all cost connected with the laying, maintaining, operating and removal of the industrial outfit on the job, but does not include cost of hauling this equipment to the job or from it to another job.

G. Mixing, placing and finishing covers all cost connected with this work, such as labor, supplies, equipment rentals, gasoline, oils, etc.

H. Curing covers all costs connected with the covering, sprinkling, uncovering and taking care of pavement while in the curing process.

I. Materials covers only the actual material costs, such as sand, coarse aggregates, steel, expansion joints, freight, demurrage, etc.

J. Shoulders covers the cost of the

CONCRETE PAVING SETUP

CLASSIFICATION	Paver #1 5 Bag Machine — TOTAL TO DATE — Quantity Work Done Sq. Yds.	COSTS Total	COSTS Unit	Paver #2 5 Bag Machine — TOTAL TO DATE — Quantity Work Done Sq. Yds.	COSTS Total	COSTS Unit
A. Moving Equipment	21499.6	529.81	.0246	95,297.9	4859.95	.0510
B. Trenching	"	1354.47	.0630	"	6006.19	.0630
C. Water Lines	"	631.82	.0294	"	2699.67	.0283
D. Forms	"	692.97	.0322	"	2659.97	.0279
E. Truck Haul	"	7704.83	.3583			
F. Industrial Haul				"	15739.44	.1652
G. Mix Place Finish	"	2654.87	.1234	"	10663.56	.1121
H. Curing	"	673.25	.0313	"	3625.30	.0380
I. Materials	"	12690.54	.5903	"	55503.48	.5824
J. Shoulders	"	1920.75	.0893	"	8513.87	.0893
L. Yard Set Up	"	778.40	.0362	"	1466.89	.0154
M. Yard Operation	"	2149.31	.0999	"	7447.35	.0782
N. Overhead	"	1585.39	.0730	"	5495.16	.0577
Total Cost	21499.6	33366.41	1.552	95,297.9	124681.03	1.308
		Average Cost is		1.353 exclusive of Cement.		

Fig. 2.—Comparison of Cost of Various Operations of Each Paving Unit

final trimming up of the shoulders. (This item is logically an excavation item, and we are now including it in a subdivision under grading.)

L. Yard set up covers the cost of moving in the yard equipment from some other project, setting all pieces up, building office, sheds, roads; in fact all expense encountered in preparing the yard for operation.

M. Operation of yard covers all cost of operating the loading yard, such as loading and unloading materials, batching of aggregates, storing tile or pipe, steel, cement, gasoline, oils, supplies, etc.

N. Overhead covers all overhead expense charged to the paving operations, such as superintendent's time, timekeepers, checkers and all other head expense proportioned against the paving operations, including general office and cost work.

Discussion of the Costs.—Item "A" (paver No. 2) greatly exceeds that of paver No. 1 in cost per square yard. This is due to the heavy expense connected with bringing the industrial equipment to the job.

On practically every other item of work the unit costs of paver No. 2 are less than those of paver No. 1. This is caused principally by the better showing made by paver No. 2 after the rainy season. In other words, if paver No. 1 could have continued approximately another month these unit costs would be practically the same with a few exceptions. Item "J" on paver No. 2 is higher than on the other setup because of the industrial track located on the shoulders, thereby causing the workmen to obtain practically all of the cover material from one side of the slab instead of from both sides.

There is also a small difference between the materials. The 0.008 ct. per square yard difference has no relation to the average paver runs, but is caused by the slightly higher freight rates on the aggregates. This job, as mentioned before, represents very closely the typical condition in Michigan and also a typical example of the methods used in obtaining the costs on many concrete paving projects.

Dragging Gravel Roads

By RALPH A. ULBRIGHT

County Engineer, Sanilac County, Michigan

During the past season I developed and adopted a method of dragging gravel and other roads of similar nature, which I have not seen advocated elsewhere. If you are using the time-honored method of dragging, I feel safe in the assurance that dragging costs will either be reduced 25 per cent, for the same conditions, or the riding surface will be improved from 25 per cent upward, should the method I suggest be adopted.

When the general order was sent out that no more dragging would be permitted on the side of the road facing traffic, we had on hand several pieces of equipment which could not be reversed, and other pieces which would not easily reverse. We were then faced with a proposition of scrapping some equipment in excellent condition, or devising a method by which this equipment could be used without violating orders.

The generally accepted method of dragging commonly used throughout the country consists of cutting out chatter bumps and other irregularities with the blade in reversed position, which places the material so cut in a ridge on the shoulder, or at the best, on the outside edge of the metal. Then the same material is brought back with the blade in normal position and ridged up to the center of the road. Unless the two operations are done with but a short interval between them, the road is often caught by a rain with a dike on each side. Such a dam prevents the free flow of water to the ditch and should never be allowed. This usually requires another cutting. Suppose, however, the rain did not materialize, the operation consists of the following, using one machine. One round trip cutting out, one round trip bringing in, one-half round trip spreading the loose material which was piled in the middle. To get the machine back to the starting point three complete trips are necessary, and if one machine has done the work and the traffic is heavy, it is time to start over again. The new method is as follows: With the blade in normal position, cut the material, the same as is generally done, but the material is placed on the metal surface near the center of the road. The best position I have found is over the center, in line with the left hand wheel track of opposing traffic.

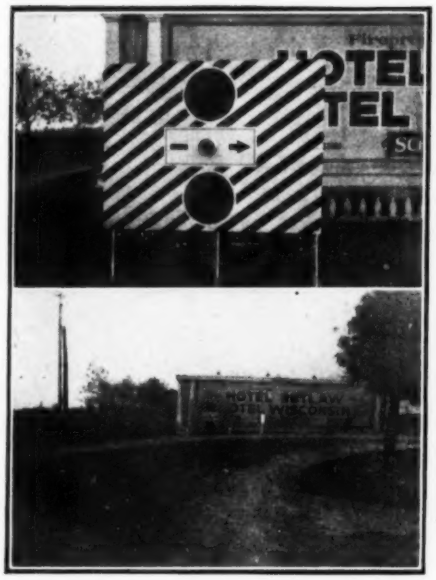
Due to the fact that the road has a crown, the loose material, instead of being piled up, will normally lie in a wedge shape beginning at the center and extending to the left. However, if the cutting is exceptionally heavy, there will be a ridge left, as before mentioned, in the path of the left hand wheel of opposing traffic. This ridge will not be as great as if piled in the center due to the wedge. Traffic has not found this objectionable. On the return trip the same operation is performed and if the road is not pitted too heavily, the loose material can be spread evenly over the center. If heavy cutting is required there will be a ridge left which is spread on the next trip. One round trip will do the work, on light cutting, or three trips of the old method, and two trips will take care of almost any condition. This method not only has the advantage of reducing trips but will keep the loose material on the metal surface where it belongs, and where it will be compacted. It is necessary occasionally to make a trip to clean up any material which traffic has scattered on the shoulder. This method also has a tendency to make a three-track road with the outside tracks well on the metal, whereas the old method forced a four-track road with the outside tracks on the edge of the metal and often on the shoulder. It will be found that as soon as this method is well started, we are maintaining a 16-ft. metal surface instead of a 20-ft., or more. This reduction of width makes it that much easier to do the work efficiently and economically, which, after all, is the objective of maintenance organization.

Acknowledgment.—The above is extracted from a paper presented at the Highway Conference at the University of Michigan.

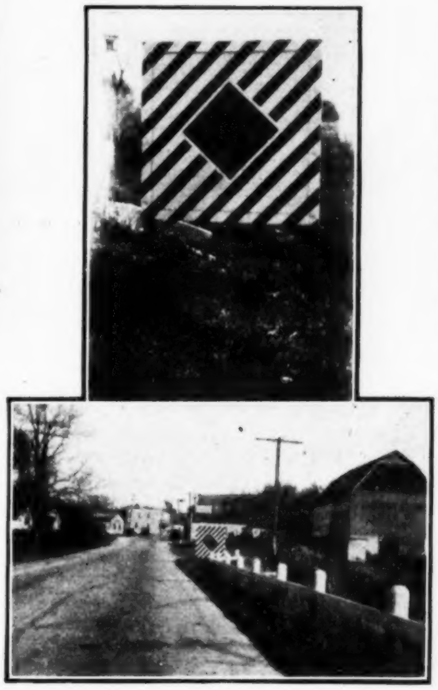
Saskatchewan, Canada, Planning Four-Year Highway Program.—Highway construction in Saskatchewan is going forward in progressive fashion. During the next four years the Provincial Government has planned to spend $20,000,000 on roads, placing greater stress on better dirt roads for the farmer than paved roads for the tourist. About $4,000,000 were spent on roads in the calendar year of 1928.

Special Warning Signs for Wisconsin Highways

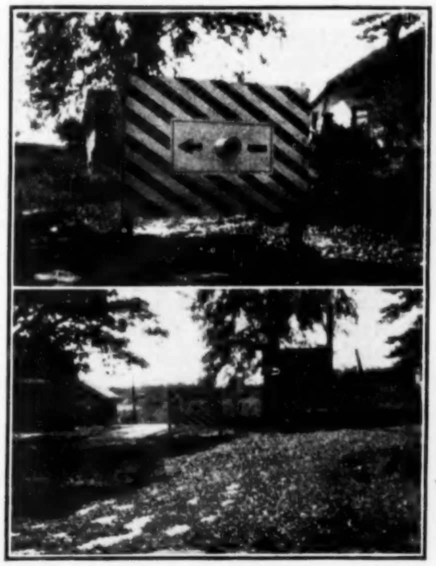
Fibre Board Signals Light, Economical, Effective



Two Views of New Type Wisconsin Warning Sign at Van Dyne in Fond du Lac County. This Sign Is of the Large Size, Equipped with Reflecting Signal, and Is Mounted on Pipe Supports



Close-Up and Distant Views of Warning Sign at Peebles in Fond du Lac County. The Effectiveness of This Sign Is Well Illustrated in the Lower Picture



This Installation of the Smaller Size of Sign Is at Genesee Depot in Waukesha County. A Reflecting Signal Is Attached to the Board, and the Board Is Fastened to the 4x4-In. Timbers with Lag Screws

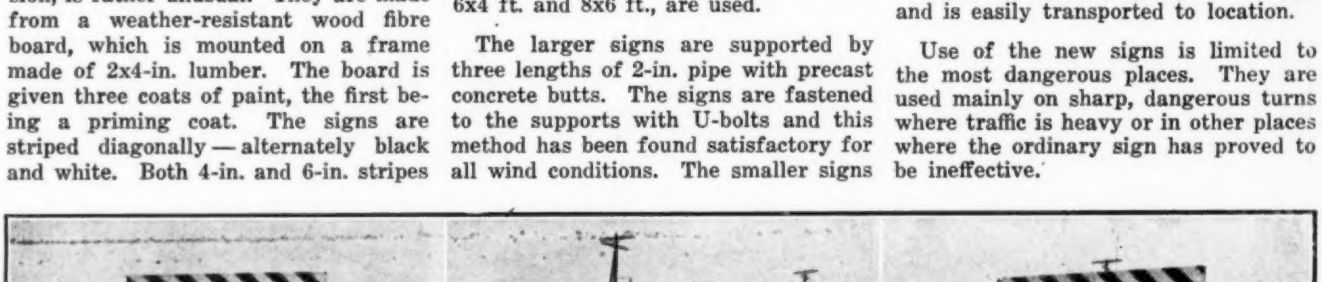
WISCONSIN, in common with a number of other states, has found it desirable to erect special signs at dangerous places on the state highway system to supplement the ordinary warnings provided at turns, intersections and railroad crossings. The accompanying illustrations show some of the installations made in Milwaukee, Waukesha, and Fond du Lac Counties which have proved particularly effective in preventing accidents.

The construction of the signs, as described by J. R. McLean, Maintenance Engineer, Wisconsin Highway Commission, is rather unusual. They are made from a weather-resistant wood fibre board, which is mounted on a frame made of 2x4-in. lumber. The board is given three coats of paint, the first being a priming coat. The signs are striped diagonally — alternately black and white. Both 4-in. and 6-in. stripes have been used and it is considered that the wider stripes have been more effective. In the center of the board is painted the standard warning or caution sign required for the particular installation. If it is thought necessary, a red or amber colored reflecting signal is placed on the sign. A great many signs, however, are erected without this signal as the painted stripes loom up plainly at night. Two sizes of sign, 6x4 ft. and 8x6 ft., are used.

The larger signs are supported by three lengths of 2-in. pipe with precast concrete butts. The signs are fastened to the supports with U-bolts and this method has been found satisfactory for all wind conditions. The smaller signs are erected on 4x4-in. timbers and fastened with lag screws.

Large warning signs placed at dangerous places are, of course, not uncommon. In Virginia, large wooden signs, striped with yellow and black diagonal bands, are placed at the sharp turns abounding on a large mileage of bituminous roads which have not benefited by relocation. Formerly, wooden signs were built in Wisconsin, the assembling and painting being done on location. With this practice, labor and the cost of material were adjudged too high and the new signs were devised as an economical measure. The new type of sign is comparatively light in weight and is easily transported to location.

Use of the new signs is limited to the most dangerous places. They are used mainly on sharp, dangerous turns where traffic is heavy or in other places where the ordinary sign has proved to be ineffective.



Three Installations in Milwaukee County. Left—Sign Ahead of Barricade in Road. Center—Sign Mounted on Movable Frame of 2x4-In. Timbers and Set on Pavement Slab Ahead of Barricade. Right—Blue Mound Road, Sign Splitting Traffic to Right-Hand Lane After Leaving Single Lane

Highway Lighting De Quindre Road, Detroit, Mich.

The De Quindre road, north of the 17-mile road around the city of Detroit, has been lighted for six miles of its length, increasing to more than 375 miles the amount of highway lights installed by the Detroit Edison Co. The extension of the lighting has been aided materially by the existence of a law in the State of Michigan permitting townships to appropriate a maximum of $2,000 annually for lighting. Before this township law was passed it was difficult for political subdivisions to raise the funds necessary to finance highway lighting systems, with the result that few miles of highway were lighted.

Night View of the De Quindre Road Lighting System

The Lighting Systems.—The systems which have been, and will be, installed consist of fixtures with 600-candlepower incandescent lamps, mounted 300 ft. apart and 30 ft. high, resulting in lighting that is stated to be practically as good as the lighting on most city streets in residential districts. Because of local laws it was not possible to install pole lines close enough to the edge of the paved road surface to employ efficiently the bracket or mast-arm fixtures; and it therefore was necessary to employ the center-span type of construction, mounting the units over the center of the roadway at a height of approximately 30 ft. from the light center. To do this an extra pole had to be installed on the opposite side from the pole line carrying the light circuit. Series circuits were employed, using IL transformers for each unit as these were found to be the most economical type of distribution.

Units Mounted Over Center of Road.—Since it was necessary to mount the units over the center of the roadway, a height of at least 30 ft. was required in order to place them out of the line of vision, thereby eliminating the possibility of glare. At such a height the effective light on the roadway was reduced, and part of it was wasted on the ditches and sides of the roadway. To concentrate the greatest amount of light up and down the roadway and downward toward the road surface, it was found desirable to mount fixtures equipped with two-way bowl refractors. These refractors, when directed so that the maximum beam of light was up and down the center of the road, were glaring; but this was overcome by turning the refractors a few degrees toward the edge of the road in the direction of traffic, with excellent results.

New Device for Servicing Units.—Because of the center span mounting of 30 ft., it was necessary to provide means of servicing the units, but tower wagons were not available. It was found that a cutout type of fixture was desirable, but the design previously used for arc lamps was not satisfactory since the circuits from the pole line to the fixture were lowered with the fixture. Such an installation was unsightly and had high maintenance because of the circuits swinging in the wind and breaking off. Furthermore, such devices would not orient the fixture when it was returned to its operating position, providing proper light distribution. It was therefore necessary to design a new device for this particular application. The design adopted, called the Form 42, consists of a combination orienting pulley and cutout, together with a new Form 45-L center span unit. Means are provided for clamping this combination rigidly to the span wire.

With this combination the secondary circuit of the IL transformer is run parallel to the span wire and connected directly to the cutout part of the fixture, which in turn is fastened rigidly to the span wire. The fixture itself is fastened to the orienting device which is attached to the end of a rope. This rope is run back to the pole, parallel to the span wire, and then down the pole to a cleat. To lower the fixture the rope must be pulled tight, thus unlatching and disconnecting the fixture and permitting it to be lowered to the ground for servicing. When the fixture is pulled back into place, the orienting device swings it into proper position for correct light distribution, and a latch holds it in place. At the same time connections between the fixture and the IL circuit are made.

Day View of the De Quindre Road Lighting System

Proposed $7,100,000 Loan for Highway Construction in British Columbia.—A bill has been introduced as a Government measure, of which one of the items $7,100,000 has been marked for road and bridge construction.

New Books

"Prometheus, U. S. A." by Ernest Greenwood, author of Alladin, U. S. A., etc. First edition, 213 pages, 5½ in. by 8⅛ in., hard cover, cloth binding, illustrated, Harper & Bros., New York City, publishers. Price $2.50.

Beginning with the tales of fire as they are chronicled in myths, legends and the history of its uses down through the ages, Mr. Greenwood considers at some length the modern methods of uses of fuels and their relative merits in industry and home. He has collected a large amount of material on oil, gas and electric light and power and has been able to sketch the picture of the distribution of these agencies for their multitudes of present-day employments. "Automatic heat," he summarizes, "is the latest achievement of man in employing fire for his comfort and for industrial purposes."

Wood is referred to as the first fuel and one of the bulwarks on which this country was built. Facts are given on the supply of wood now available and what is being done to assure a continuing supply for future generations, pointing out that wood is no longer to be considered as a major fuel.

In summarizing the part that coal has played in the history of fuels, the author says,

". . . to coal goes the credit for building the very foundations of American industry and it will be a long, long time before it is entirely replaced by oil, water power or some synthetic fuel of the future.

"Without coal, our transportation system, the greatest in the world, would still be in its early stages of development. Coal was an important necessity in the smelting of iron so necessary for the rails and the equipment of our railroads. Coal was the only kind of fuel that was available in the early days; how far would our railroads have travelled if they had had to depend on wood? Coal was an absolute necessity to run the industries which eventually produced the machinery from which our water-power generating plants are built."

Following this, the gas industry is discussed, Mr. Greenwood citing instances of its early discovery and the difficulties that attended its commercial introduction in the last century in England and America. He includes a considerable amount of statistical information about the industry as it exists in this country today, pointing out that, as is the case with the light and power companies, gas companies necessarily are monopolies in the communities they serve. Other sections of this discussion deal with who owns the gas companies; coal as direct fuel and as raw material for making gas; coke and other byproducts.

About automatic heat, as it is supplied by the modern oil burner or the modern gas heater, he says; in part: "There are many things of social significance which are accomplished by automatic heat aside from pushing into the background another piece of the ugly machinery of life. The growing desire for apartment house life is due, to a considerable extent, to the dread of the furnace in the basement. No one who has ever tried it will deny that the private house provides a far more satisfactory home life, particularly when there are children, than the apartment, which at best always has something of the atmosphere of a hotel and which almost always lacks the comfort of spaciousness to be found in even the most humble of dwellings."

"Prometheus" is easy to read. And it is a welcome addition to the library of popular books dealing with Industrial America.

"Economics of Highway Bridge Types" by C. B. McCullough, Bridge Engineer, Oregon State Highway Commission; Member American Society of Civil Engineers; Member Oregon Bar; Special Lecturer in Structural Engineering, Oregon State College. First edition, 246 pages, 5¾ in. by 8½ in., hard cover, cloth binding; Gillette Publishing Co., Technical Publishers, 221 E. 20th St., Chicago, Ill., publishers. Price $5.00 net.

You have often heard the expression, "He could not see the forest because of the trees." The function of this book is to place the reader on a hill or in an airplane, as it were, to survey the forest. In other words, McCullough analyses the crossing problem from the broad viewpoint of selecting an economic type of bridge from amongst the many types that may be constructed.

This text has been compiled with a view to its utility not only to the practicing highway engineer, county engineer, city and consulting engineer, but to the undergraduate student in highway and civil engineering as well.

A prominent feature is the fact that the discussion has been prepared for the highway engineer in general rather than the highway bridge engineer.

The many cost and quantity curves and data sheets have been made sufficiently general in application to cover average practice and govern estimates of cost of structures designed according to general practice. The tables and curves should prove of great benefit to the engineer in the field engaged in highway location or relocation, to highway maintenance engineering organizations and to field parties, divisional organizations, municipal and county engineers and others engaged in the construction, location or design of highway bridges.

To the student in engineering this work should serve a two-fold purpose. First, as an outline of bridge economics and type selection in general it serves to direct his attention to a most important phase of bridge engineering and one to which scant time is given in most engineering curricula. Second, the many cost tables, curves and illustrations, covering in fact practically all of the commonly employed types in highway bridge construction, will serve to give him a rather thorough and comprehensive survey of the ordinary construction types, these affording him an opportunity to develop the necessary and much to be desired general perspective of the subject before taking up the complicated minutia of design and design methods.

"India in 1927-28," by J. Coatman, Director of Public Information, Government of India; First edition, 461 pages, 6 in. by 8¾ in., hard cover, paper binding; Government of India, Central Publication Branch, Calcutta, India, publishers. Price, Rs. 2-8 or 4s. 6d.

This report examines the political tendencies of the year; it emphasizes the complexity of the subject and shows that the feature of the new constitution, now under examination, has been the growth of provincial consciousness leading to "the increasing importance of provincial politics as compared with all-India politics." The political groupings in the provinces have been on communal rather than on ordinary party lines.

The book also discusses commercial and economic phases of India's progress.

"Plain Concrete," by E. E. Bauer, B. S., C. E., Instructor in Civil Engineering, University of Illinois; Associate Member American Society of Civil Engineers; Member American Concrete Institute; Author of "Highway Materials." First edition, 346 pages, 5¾ in. by 9 in., illustrated, hard cover, cloth binding. Price, $4.00.

This book is a good general discussion of the process and results of the manufacture of concrete. The methods of making concrete are discussed briefly from the selection and preparation of materials to the final sampling and testing. Purposes and values of the various tests are treated and specifications of the American Society for Testing Materials quoted wherever available.

Other subjects covered are: field control methods, high-early-strength concrete, workability, waterproofing, estimating quantities of materials, specifications for concrete construction, sampling and testing.

"Practical Railway Painting and Lacquering," by Hengeveld-Disney-Miskella. First edition, 242 pages, 6 in. by 9 in., hard cover, cloth binding; Volume IV of the Practical Finishing Series. Simmons-Boardman Co., New York City, publishers. Price, $3.50.

This is a discussion of the practical methods of spray painting. All pieces of equipment are discussed for spray painting, using different kinds and types of paints and coatings. Sand blasting, cleaning and polishing methods are clearly discussed.

Six Year Highway Program for Mexico.—The Ministry of Communications of Mexico has issued a statement that the Government had prepared a highway construction program calling for an expenditure of $39,564,000 during the 6-year period 1929-1934, to be expended by years as follows:

1929, $3,860,000; 1930, $5,800,000; 1931, $6,755,000; 1932, $7,237,000; 1933, $7,720,000; 1934, $8,202,000. The sum of $4,825,000 is to be expended for maintenance.

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The Gasoline Tax, Pro and Con

Glenn Griswold, the editor of the Chicago Journal of Commerce, insists upon calling the tax on gasoline a "nuisance tax." There is, of course, no logical argument in applying opprobrious epithets; but if any advantage in debate is to be gained by using such epithets, perhaps we may even up the handicap by replying that every tax is a nuisance.

Studying Mr. Griswold's real arguments against the gasoline tax, they simmer down to two: First, that it is not a sound policy of taxation to apportion the tax burden according to the individual benefit derived from the expenditure of the money raised by taxation. Second, that once the door is opened to the practice of taxing gasoline, abuses may ensue through excessive taxes on gasoline.

This second objection may be dismissed at once as being no objection to the gasoline tax but only to an unjust or unwise rate of taxation on gasoline. Abuses there are in every system of taxation, and they seem to favor no particular form of taxation. Flagrant injustices abound in the income tax, yet income taxes of some sort may be justified.

The first objection amounts to this: If Smith uses the highways more than Jones, and does not use them for Jones' benefit, it is proper to make Jones pay as much as Smith for the use of the highways. With such a proposition few men, other than socialists, will agree. Mr. Griswold argues that if taxes should be apportioned according to the use made of public property, then the Michigan Avenue bridge in Chicago should be converted into a toll bridge. If the expense involved in collecting the tolls plus the expense involved in the traffic congestion accompanying such a method of collecting taxes were very slight, our reply is that it would be good public policy and equitable to convert Michigan Avenue bridge into a toll bridge. But it is obvious that in such cases the slight sum collected from each user of the bridge, if it were enough only to pay his share of interest and depreciation on the bridge, would exceed the value of his time in stopping to pay the toll; for such stopping on the part of every vehicle would cause such congestion of traffic as to amount annually to vastly more loss in dollars of time-value than the interest and depreciation on a score of Michigan Avenue bridges. Incidentally, this would be a Nuisance tax with a big N; and we suspect that it is just such forms of lost time and other indirect expenses that have led to the expression "nuisance tax."

In the case of the gasoline tax no such "nuisance" exists, for the paying of the tax (which is really a toll paid for the use of the highways) does not delay traffic, and the cost of collecting it is nominal.

Mr. Griswold suggests that it would be just as equitable to tax each barrel of cement that goes into a road as to tax each gallon of gasoline used in propelling vehicles over the road. This argument fails to recognize the fact that the taxing of cement fails to apportion the tax in proportion to the use of the road. It would increase the cost of a cement highway by the amount of the tax on the cement, but this would serve only to pass tax money from the left pocket to the right pocket, and wouldn't alter the taxpayer's ultimate bill, except by raising it somewhat to cover the cost of collecting the cement tax.

Mr. Griswold grants that the gasoline tax is about as equitable a tax as could be devised, but he says: "Academic theories of taxation equity may be forgotten," by which he evidently means that it is impracticable to secure equity in taxation. We grant that it is very difficult to secure such equity, but we fail to see why an admittedly equitable tax levy should be avoided merely because there are other tax levies that are not equitable. This savors of pleading general disobedience of law as a reason for not obeying a given law.

The World's Need of Researchers

Scientific research began scarcely more than three centuries ago, with Galileo, Kepler and Gilbert. Marvelous as its achievements have been, perhaps a greater marvel is that they are the accomplishment of relatively few men. It has been the custom to explain this fact by saying that genius is a rare gift. Yet, if the phenomenon is purely one of difference in mental power, and in the rarity of that supreme power called genius, how comes it that there were almost no scientific geniuses prior to about the year 1600? Scientific genius did not suddenly evolve at that time in a few humans. We must therefore infer that men had not till then learned how systematically to interrogate Nature so as to secure definite answers to their questions.

Although this explains, in a general way, the birth of modern research, still it leaves unexplained the fewness of researchers. Even yet their number is pitifully few when contrasted either with the total population or with the economic needs of that population. Doubtless much of the reason for so little researching springs from general ignorance of the nature of research. This ignorance has served to cast a screen of mystery about the art, leading to the belief that only a few divinely gifted mortals can successfully penetrate the winding labyrinths that lead to Nature's holy of holies.

Germany has done more than any other nation to dispel this particular delusion. By training thousands of young men in research methods, German universities have proved that research ability is by no means rare. But, even in the face of such proof, America has been exceedingly slow in entering upon a career of scientific research. Most of us still regard successful research as a thing unteachable, and confined to a gifted few who will somehow or other develop their native talents even in the face of public indifference and in the absence of pecuniary support.

This last clause gives the clue to much of the apathy

toward research by men capable of research. The spirit of martyrs is usually found only where public applause accompanies self sacrifice. Many a man will bravely hurl himself into any breach if he knows that his bravery will be appreciated by his fellow men. But when self-sacrifice brings not even a murmur of approval, it becomes a rare thing. The self-sacrifice of the scientific researcher is of this latter sort. He would starve in a garret if assured glory were the reward; but almost the only reward for his research work is apt to be his daily wage, for his renown will probably not extend beyond the ranks of the very few of his own scientific class who are capable of appreciating his achievement. The wonder is that these few are not fewer.

Up to very recently scientific research was almost entirely in the hands of a few college professors. Small as the salaries of such men have been, still the income served to maintain them, and their daily duties were such as to leave some freedom for investigating natural causes and effects. If even such scant support has served to develop a body of researchers whose achievements have already revolutionized industry, imagine what might have happened in the past three centuries had the same support been provided for ten times their number.

We venture to say that not a single one of the major death-dealing diseases would remain unconquered had ten times as many biological researchers been engaged in seeking causes and cures. We are so sure that successful research is teachable, and that native research ability is not rare, that we regard it as certain that multiplying the number of trained researchers by ten would multiply the discoveries by ten. Indeed, we may safely go much farther, for each discovery itself throws light on other research problems. Hence discoveries tend to multiply in a sort of geometric progression. This is one of the reasons for the startlingly rapid advance of science within the last generation. Another reason is the pecuniary support of research laboratories by many industrial corporations. At last "big business" has begun to see that behind the inventor is the research scientist who furnishes him with his basic ideas; and that behind both inventor and scientist there must be dollars if the combined achievements of these two groups are to be rapid and great.

Take the element of time. Where Goodyear labored the better part of a lifetime to learn how to vulcanize rubber, a great modern chemical research laboratory would probably accomplish the result in a year. In the place of one Goodyear there would be a score of chemists. In the place of his kitchen chairs and tables, burned in that last fine frenzy to keep the rubber in the pot boiling while he added sulphur, there would have been exhaustless fuel.

All honor to Goodyear the Gritty, to Goodyear the Great! But where is there any honor for his blind contemporaries? Neither praise nor pay did they give him, but left him to fight his research battle alone. Does this indicate at that time a public ignorance almost barbaric? It does, and scarcely less is the ignorance of the public of today. Scourged by diseases, poverty stricken as to nine-tenths of this globe, the world is still so ignorant of what research science could do to remove these blights on health and happiness that it looks with bovine eyes at its ills and never dreams that cures are to be had. Its suffering is pitiful; its ignorance is appalling.

The Need of Political Engineers

In a recent editorial article we said: "If engineering is the application of science to problems of economic service, then engineers should not hesitate to extend their activities into the uttermost parts of the social realm. Certainly there is as much need of scientific study of the economic effects of laws and ordinances as of the scientific study of strains and stresses. Who, we ask, is better equipped for such study of political economics than is the engineer?"

We were speaking of laws that relate to taxation for street improvements, all of which, in our opinion, are archaic and act to obstruct progress in city highways. Bottle-neck streets and bumpy pavements disgrace nearly every city, yet we go somewhat complacently, even though swearingly, along, making no effort to change the laws that place the entire burden of cost of all street improvement upon the owners of abutting property. That burden surely should be distributed, and the failure to distribute it accounts mainly for the prevalence of poor pavements and congested city thoroughfares.

City engineers encounter many another law or public practice that is detrimental to progress. For example, the net income of water departments usually becomes part of the general fund, and is often used for purposes entirely foreign to furnishing an adequate supply of pure water. There is no defense for such practice, except that "it has always been the practice." As a result of it, and because of certain laws, the taxpayers are often called upon to vote upon major improvements in, or extensions of, the waterworks. It needs no argument to prove that voters can not decide such matters intelligently. As well ask voters to diagnose the cause of a disease, or to prescribe its remedy.

Living in a democracy has served to blind most of us to the foolish practice of asking voters to solve economic problems relating to public affairs. If it be answered that the voters are not usually asked to solve such problems, but are merely asked to decide whether a given public improvement should be undertaken, our reply is: One of the most important, and often the most difficult, of economic problems is the determination of whether a proposed improvement should be undertaken at all. In his "Economic Theory of Railway Location" Wellington repeatedly emphasizes the economic importance of determining first of all whether a proposed railway will be profitable. His preface contains his justly celebrated definition of engineering, and his ridicule of the type of "engineers" that put multitudes of men to work needlessly.

Civil engineers have usually been content to let the voters or the directors of companies tell them when and where to build structures, without often attempting to express an opinion as to the economic wisdom of the project. Our contention is that this attitude toward a major economic problem is unwise, and that the public should be taught to seek the advice of engineers and to act upon that advice, not merely as to the design of a structure but as to the wisdom of building it. It will involve years of effort to bring about such a change in general practice, for there are not only public inertia and ignorance to be overcome, but many laws to be wiped off the statute books.

Bucyrus-Erie Adds ½-Yd. Gasoline-Power Crane-Shovel

The new 1020 Bucyrus-Erie ½-yd. crane, which was exhibited at the Cleveland Road Show and which is the smallest in the complete Bucyrus-Erie line (ranging from these ½-yd. machines to the gigantic 16-yd. strippers) is standard equipped with a 48-hp. gasoline motor, making it the most powerful crane and shovel of its size.

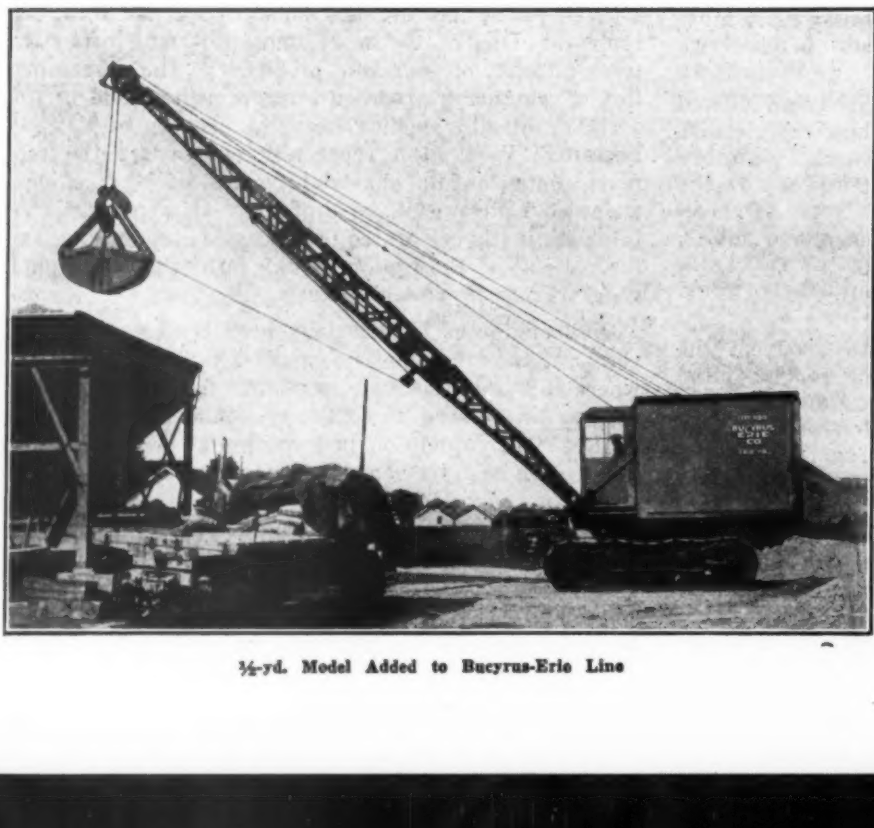
This extra margin of power enables the 1020 to handle harder excavation and heavier crane work. It also makes faster operation possible throughout the entire operating cycle. Extra strength has been built into the machine throughout to insure trouble-free service in the harder digging and at the faster pace which the machine is capable of handling. Features have been incorporated; such as a one-piece steel truck frame and turntable, enclosed gears running in oil, and anti-friction bearings on all high speed shafts.

To insure easy mobility, the weight of the Bucyrus-Erie 1020 has been kept as low as is consistent with the necessary strength to handle the hardest work. Weight has been eliminated wherever possible without sacrificing strength, reliability being the standard for this machine.

In design, the 1020 is practically a smaller duplicate of the Bucyrus-Erie 1030, the ¾-yd. gasoline shovel, crane, and dragline. The only difference between the 1020 and 1030 is that of size, weight and price.

The 1020 is offered by Bucyrus-Erie as a crane, dragline, shovel, or dragshovel. Convertibility has been carefully planned for in designing the machine, and it can be easily and quickly changed over from one type to another, as required. It is also furnished as an electric machine where electric power is available.

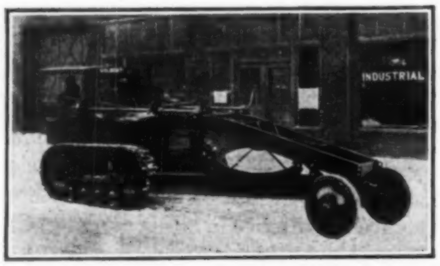
For more details write to Mr. F. O. Wyde, advertising manager, Bucyrus-Erie Co., South Milwaukee, Wis.



½-yd. Model Added to Bucyrus-Erie Line

Trackson-Gilbert Combination Developed

Economy is becoming an increasingly important factor in the selection of highway and construction equipment, and today public officials, contractors, and other users realize that the best economy is to buy machinery that is adaptable to many kinds of work and that can be used the year-around.



Model DH Trackson McCormick-Deering and Gilbert One-Man Grader Combination.

Small or medium-size crawler tractors like the Trackson McCormick-Deering provide economical power for various purposes. These units are all-season equipment, useful for winter work as well as for road construction and maintenance, dirt-moving, hauling and many similar operations in the spring, summer and fall.

The model DH Trackson and Gilbert grader unit is a new combination that fills the bill in every respect, the manufacturer claims, for a heavy-duty, one-man motor patrol, and at the same time provides a crawler tractor which may quickly be made available for other kinds of work. The speed and simplicity of either mounting or detaching the grader and the quick interchangeability of the Trackson McCormick-Deering are the most important advantages of this unit. There are no special parts necessary for the installation, and it is only about a four-minute job to remove the grader from the tractor, leaving a complete, crawler-equipped power plant which is adapted to alrge variety of jobs.

With the grader detached, the Trackson may be put to work immediately hauling dirt, rock, and other materials. Or, it may be quickly and easily equipped with another auxiliary attachment such as a loader, shovel, hoist, crane, bulldozer, etc. Because of this versatility the Trackson McCormick-Deering may be used as a road work and general utility tractor, and during the winter may be equipped with a heavy-duty snow plow to keep the roads open to motor traffic. Thus the equipment dollars of the county, township, or individual owner are used more economically.

The Trackson Company also manufactures a lighter crawler for the McCormick-Deering industrial tractor, which is likewise adapted to road work, general construction, snow removal, etc. The Gilbert grader is made by the Gilbert Manufacturing Company, Stillwater, Minn.

New Hoist Announced

The American Hoist & Derrick Co. announce the development of a new hoist which is powered with a Waukesha gasoline motor the same as previous American gasoline hoists. The power is transmitted to the hoist by means of a silent chain drive and is delivered to what would be the crank shaft on a steam hoist; the logical place to apply the power. The American two-speed drag scraper hoist, when mounted on a 5-ton motor truck, constitutes the power plant of a portable dragline installation. Drop a line to the American Hoist & Derrick Co., 63 S. Robert St., St. Paul, Minn., and they will send you more detailed information about these hoists.

Hoist Announced by American Hoist & Derrick Co.